Popular Astronomy

Vol. LIX, No. 3 MARCH, 1951 Whole No. 583

Leslie John Comrie
1893-1950

By CHARLES H. SMILEY

Leslie John Comrie was born in Pukekohe, New Zealand, on August 15, 1893. He received his early education at the Auckland Grammar School. At Auckland University College, he held the Sir George Grey Scholarship and the Senior University Scholarship, graduating in 1914 with the degree of A.B. In 1916, he received the degree of M.A. with honors in Chemistry from the University of New Zealand.

He served for three years in the New Zealand Expeditionary Forces in the First World War; then for a year he studied at University College, London, and became acquainted with calculating machines in the classes of Professor Karl Pearson. Thus began an interest which led to some of his most important work.

In 1919, he moved to Cambridge University where he held a New Zealand Expeditionary Force Scholarship and later the Isaac Newton Studentship. He received his Ph.D. from Cambridge University in 1923; his thesis was in the field of mathematical astronomy.

He came to the United States for several years, serving first as Assistant Professor of Mathematics and Astronomy at Swarthmore College from 1922 to 1924 and later as Assistant Professor of Astronomy at Northwestern University from 1924 to 1925. In 1925, he was recalled to England to become Deputy Superintendent of H. M. Nautical Almanac Office in the Royal Naval College, Greenwich, and in 1930 he succeeded P. H. Cowell as Superintendent. During his period of service in the Nautical Almanac Office, he introduced many innovations in the methods of computations employed there. He was especially clever at using, for complex scientific computations, machines which had been designed for ordinary business purposes. Among these were the Hollerith punched-card machines and the National multiple-register machines. He would prepare a routine so simple and so clearly defined that ordinary office clerks could carry it through efficiently. In 1929, with the Hollerith machines, he was busy preparing for a century ahead, the basic material from Brown's tables of the moon, from which the lunar data in the annual ephemerides could easily be derived.

He prepared a series of tables by which, by end-figure methods, a table could be interpolated in tenths and subtabulated. These tables with his explanations of their use appeared in the *Nautical Almanac* for 1931 and were later reprinted as a separate booklet. He was careful

to point out that end-figure methods had been in use for some time, and that his contribution had been in providing tables facilitating the use of these methods. He also pioneered in the use of multiple-register machines in the construction of tables from n-th differences. The great advantage of this procedure is that, with Comrie's clever methods for the automatic rounding-off of tabular values, it provides the equivalent of proof-read printer's copy. A number of other national ephemerides have adopted this method and, by using photographic printing processes, have avoided the cost of setting up type and of proof-reading the pages of tabular material.

Much of the success of modern electronic calculating machines can be credited to the pioneer work of Comrie. When he had set up routines so simple that ordinary office help could carry them out, it was only an additional step for others to invent electronic devices to do the things the clerks had been doing.

Many of Comrie's papers in astronomy concerned the prediction and reduction of eclipses and occultations. He was responsible for many improvements in these fields. He was also an outstanding expert on the genealogy of tables. Several men who published tables which they had copied from other earlier tables and claimed as their own original work, learned, to their embarrassment, that he had an excellent collection of lists of errors in mathematical tables, especially tables of natural trigonometric functions. He was absolutely fearless in denouncing these plagiarists.

He served as secretary of the Mathematical Tables Committee of the British Association for the Advancement of Science for seven years, 1929-1936. Five volumes of tables were published and several others were started in this interval. While he was engaged in this work, Comrie developed the methods of subtabulation which have proven so valuable.

He served as one of the editors of *Mathematical Tables and Other Aids to Computation*, a quarterly journal published by the National Research Council (U.S.A.), from its origin in 1943 until January, 1950. He edited the third and fourth editions of the very useful volume, Barlow's "Tables of Squares, Cubes, Square Roots, Cube Roots, and Reciprocals of all Integer Numbers up to 10,000." The number of pirated editions of these tables may be taken as a compliment for Comrie's work. With J. T. Peters of Berlin he prepared two volumes of approximately 900 pages each of natural trigonometric functions to 7- and 8-figures, respectively, for every second of arc.

In 1932, he gave a six weeks' summer course on calculating machines at the University of California at Berkeley. He gave series of lectures on the same topic at Imperial College and at University College of the University of London. He served as President of the International Astronomical Union Commission on Ephemerides from 1932 to 1938.

In 1936, he left the British Nautical Almanac Office and not long

thereafter founded a novel organization, Scientific Computing Service, Ltd., which offered to undertake scientific calculations, especially those problems where a considerable amount of work was involved and where his "mass-production" methods could be employed to good advantage. He particularly solicited table-making. The success of this organization which he headed until his death is indicated by the difficulty he had in finding time for a vacation.

Although he was always a busy man, Comrie found time to lend his support to the British Astronomical Association, serving this amateur group in various capacities through the years. He was also very generous in helping many a young scientist in visiting England for the first time.

Among the honors which came to him were: honorary member of the New Zealand Astronomical Society in 1933, fellow of the Royal Society of New Zealand in 1945, and fellow of the Royal Society of Great Britain in 1950.

In 1920, Comrie married Noeline Dagger of Wellington, New Zealand. He had one son by this marriage. In 1933, he married Phyllis Betty Kitto who survives him. On the night of December 10-11, 1950, he passed on peacefully in his sleep. Though he delighted to call himself a "machine crank," his friends will remember him as one whose strong interest in his chosen field did not keep him from helping others.

Brown University, Providence, R. I.

Motion Pictures as an Aid in Teaching Astronomy

A Report to the Teachers' Committee of the American Astronomical Society*

The use of motion pictures in the teaching of science has been criticized for dogmatic presentation, for confusing theory with fact, and for misinforming students, on the one hand. On the other hand, supporters of their use point out that films can portray complex phenomena more efficiently than experiments or direct observations, and can illustrate theoretical constructs more effectively than models or diagrams. Two of the series of reports of the Instructional Film Reseach Program at Pennsylvania State College are particularly pertinent to this problem: "Incidental Report No. 2; *Some Aspects of Learning from Films*," June 21, 1949, and "Special Report No. 1, *Practical Principles Governing the Production and Utilization of Sound Motion Pictures*," August 1, 1950. Parts of these reports are reproduced in the Appendix.

In an effort to explore just how far the teachers themselves feel that

*Presented to the Council on December 29, 1950. Revised by the undersigned on January 10, 1951.

films can be used in the teaching of astronomy, and to ascertain the limitations of existing films, a questionnaire was circulated among those teachers who expressed interest, and who could arrange to view classroom films conveniently with their classes. Four films kindly loaned by the Encyclopaedia Britannica Films, Inc. (EBF), were sent to several teachers for comment and were also discussed after a special showing to some thirty teachers at the June, 1950, meeting of the American Astronomical Society in Bloomington, Indiana. Moreover, numerous personal discussions were undertaken with both high school and college instructors in West Virginia, Massachusetts, Ohio, Michigan, Illinois, Wisconsin, and California.

Because of the small number of astronomy teachers, the nature of the questionnaire, and the use of personal discussion, no statistical analysis of opinion is practicable. This report is based, primarily, on the views prevailing among teachers of astronomy at the University of Arizona, University of Chicago, Harvard School of Education, University of Michigan, Northwestern University, Vanderbilt University, University of Wisconsin, and, secondarily, on briefer statements from other teachers at the A.A.S. meeting in Bloomington and on personal discussion. Most of the detailed opinions are from college teachers between 35 and 45 years of age. No other obvious selection effects are immediately apparent. Although a few teachers collected first-hand student reactions to specific films, these are too few to be statistically reliable.

In order to keep the opinions realistic, most of the questionnaire and discussions concerned four EBF classroom films on astronomy. However, the general comment on the use of films in teaching astronomy will be presented here before the compilation of comments on these films. Conclusions are given in a separate section at the end.

General Comment

The Proper use of Films. There is general agreement that classroom films can be used at the college level, by competent instructors as an adjunct (a) in presenting the phenomena of science and (b) in explaining complex theoretical constructs. A vocal minority feels strongly that these two functions should be sharply separated; the majority are not greatly concerned about distinguishing between fact and theory.

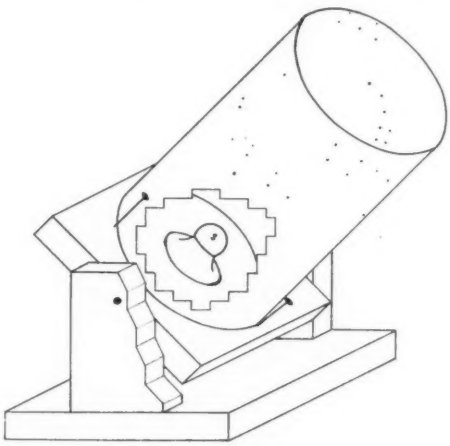
It should be noted that many high schools include astronomy in general science courses, yet do not have instructors trained in astronomy; therefore films to be used in high schools must be clear, accurate, and sufficiently complete to leave no major misconceptions. This last requirement is in such conflict with the use of films at the college level that it seems to some to be impossible to produce good films which can be used effectively at both levels. (See Appendix II.)

Films have been used both at the start of a class, with ensuing discussion, and at the end of a lecture which covered the film topic. A

majority of 50 students who were asked specifically if they objected to the darkened room (which may prevent note-taking), replied in the negative. The research at Pennsylvania State College has shown that note-taking during film showing is not conducive to effective learning, in any case.

Technical Difficulties. Several teachers explained that they would use classroom films regularly but for the difficulty of obtaining projection equipment in their institutions.

Films vs. *Models.* There is no general agreement on this basic point. A few teachers feel strongly that present films are more effective than models can ever be, and others feel equally strongly that no film can match a model. A large number would judge a film or a model on its individual merits. Almost every astronomy teacher recognizes the value of a planetarium (here considered a model), although a majority do not have access to one for their classes. In view of the effectiveness of the simple "tin-can planetarium" demonstrated by Fletcher Watson at the



TIN CAN PLANETARIUM

Holes punched in can with steel phonograph needle cast spots of light on ceiling. Can is rotated by hand about 6-volt lamp. Can base is tilted to change altitude of pole. (For further description see "The Science Teacher" for November, 1950.)

Bloomington meeting, it is doubtful that any teacher would prefer films to demonstrate diurnal motion. However, a majority of teachers lacking access to a more complete planetarium favor the use of films illustrating motions of the sun and planets.

Suitable Film Topics. A large number of suggestions were received concerning topics useful for astronomy classroom films. These have been compiled in a single list below. There is general agreement that present films include too many topics in one film (see Appendix II and III);

therefore the following list of suggestions includes a number of topics which overlap with presently existing films (listed below), several of which should be broken down into two or three separate films.

The Solar Motion: Animated diagrams of proper motions, radial velocities, etc. Show catalogs. Blink comparator in use, plate measuring engine, etc.

The Galaxy: Milky Way photographs, animated diagrams of galactic rotation. Globular clusters, interstellar obscuration, etc.

Time: Solar day, sidereal day, month and year illustrated with animated diagrams. Pendulum clocks, crystal and NH_3 clocks. Use of transit.

Telescopes and Observatories: Animated diagrams of refractor and reflector, elements of telescope design illustrated by shots of famous telescopes from Galileo's to Hale's.

Astronomical Spectra: Animated diagram of spectrograph. Spectral types, radial velocities, peculiar spectra, and animated models of peculiar stars.

Explosions on the sun or *The Sun's Atmosphere:* The Michigan or Harvard film, edited, with animated diagrams of a spectroheliograph and coronagraph.

Nuclear Energy: Animated diagram illustrating solar energy output, measurement of solar constant, animated diagrams of nuclear reactions, electrostatic ion accelerator, nuclear pile, animated diagrams of the Bethe cycle, of the proton-proton reaction, etc.

Cosmology or *Beyond the Milky Way:* Nebular types, inverse square law, nebular surveys to different distances, animated diagrams of expanding universe and curved space, etc.

Radio Astronomy: Directional radio receivers, interference technique, animated diagram of a sweep across the Milky Way and Cygnus hot spot, etc.

Aurorae: Forms, correlation with solar activity, animated diagram of theoretical explanations, spectra, etc.

Films Available

At this point it is appropriate to list the films presently available which might be used in astronomy courses. The following list is extracted from the University of Michigan Audio-visual Education Center catalog of motion pictures (Ann Arbor, 1949) with a few additions.

Aerial Navigation			
I. Maps and the Compass		10^m	USOE
IV. Radio Aids		26^m	USOE
Celestial Navigation.			
Part I, Introduction		18^m	USOE
Part II, Principles		17^m	USOE
Part III, Charts		19^m	USOE
Part IV, Our Earth		17^m	USOE
Earth in Motion		10^m	EBF
Exploring Space		10^m	TFC
Exploring the Universe		10^m	EBF
The Moon		10^m	EBF
Surveying Lunar Craters (?)		?	U. of M.
Navigation: Nautical Astronomy		24^m	USOE
Navigation: Star identification		17^m	USOE
The Solar Family		10^m	EBF
Solar Prominences		10^m	U. of M.
Explosions on the Sun	(no sound)	?	Harv.
Story of the Telescope		10^m	KB
Light Waves and Their Uses		10^m	EBF
Behavior of Light	(no sound)	15^m	EBF
Atomic Energy		11^m	EBF
Introduction to Optics		17^m	USOE
Lenses	(no sound)	15^m	EBF
Optical Instruments	(no sound)	10^m	EBF
The Nature of Color	(color)	10^m	?
The Story of Palomar	(black or color)	?	EBF

Note: The prices of these films are not all available. The 10-minute EBF sound films, black and white, may be purchased for $50.00 each or rented for $2.50 for 3 days. Most of the films are available for rent from the producer indicated and from State University Extension Services.

Abbreviations:

USOE = U. S. Office of Education, Washington, D. C.
EBF = Encylopaedia Britannica Films Corp., Wilmette, Illinois (formerly ERPI).
TFC = Teaching Films Custodians, Inc., New York, N. Y.
U. of M. = University of Michigan, Ann Arbor, Michigan.
Harv. = Harvard University, Cambridge, Mass.
KB = Knowledge Builders, New York, N. Y.

Comment on EBF Films

The following comments refer explicitly to the four EBF Films,

(1) *The Earth in Motion*, produced in 1934,
(2) *The Moon*, produced in 1936,
(3) *The Solar Family*, produced in 1934, and,
(4) *Exploring the Universe*, produced in 1936.

which were viewed for this survey by 10 teachers with their classes, and some 30 teachers at the Bloomington A.A.S. meeting. The critical nature of these comments is due in part to the fact that criticism was invited; there is no intention to belittle the value of these films, which were chosen as a basis for this report because they are so widely used.

A majority feel the "age level" of these films is too low for use at the college level. This criticism seems to be aimed primarily at the narration, both its content and tone, as well as the extraneous "human interest" sequences (*e.g.*, Arctic dog sleds in *Exploring the Universe*). One teacher's suggestion was to replace the "radio announcer" with a "serious astronomer." However, a small minority of teachers feel that students like these extraneous comments and shots. (See also Appendix III for comments on relevance and on humor in instructional films.) A poll among 60 students at Northwestern and the University of Wisconsin showed that over 33% felt the narration was beneath them, although a large majority liked the films and felt they learned a good deal from them.

A majority of teachers feel that the length (10 minutes each) is about right, but that too much material is included in each film. A suggestion which received considerable support was that each of the films (2), (3), and (4) should be split into two or more, with possible titles *The Moon, The Moon's Surface, The Solar Family, The Origin of the Solar System, Motions of the Stars, The Galaxy*, and *Beyond the Milky Way*. However, the present films can be used effectively by showing them in part, or by showing them two or three times. (See also Appendix II.)

About half the teachers surveyed do not use the films in their classes, but those who have used them have continued to do so, and feel they are valuable in their present form. About half the teachers surveyed include laboratory work in their elementary courses, but the laboratory work seems neither to preclude nor to be precluded by the use of the films.

Somewhat more specific comments concerning these films are the following:

(1) *The Earth in Motion* (produced in 1934 by ERPI in collaboration with Walter Bartky, University of Chicago).

Commendable features: Measurement of size and mass of earth, disappearing ship, parallax demonstration.

Questionable features: It is not noted that the yearly progression of constellations does not prove revolution of the earth about the sun. The earth is shown at aphelion at the wrong date.

Suggestions: Add V-2 rocket pictures showing curvature of the earth, add Willy Ley drawings.

(2) *The Moon* (produced in 1936 by ERPI in collaboration with Walter Bartky, University of Chicago).

Commendable features: Explanation of tides, motion of earth and moon about sun, sidereal *vs.* synodic period, sunrise and sunset on moon.

Questionable features: Reason for lag of tides not clear. Too much emphasis on tides with no mention of lunar surface features and theories of their origin. The moon's shadow moves the wrong way in the animated diagram of a total eclipse. The earth's shadow moves the wrong way across the moon in the lunar eclipse.

Suggestions: Break into two separate films, one covering lunar surface features.

(3) *The Solar Family* (produced in 1934 by ERPI in collaboration with Walter Bartky, University of Chicago).

Commendable feature: Relative motion of the planets.

Questionable features: Too much discussion of the obsolete Planetesimal Hypothesis. No attempt is made to eliminate the misconception of the relative sizes of sun and planets necessarily produced by the animated diagrams. No mention of inclinations of planet orbits. Lighting is poor on some animated diagrams. Too much is covered.

Suggestions: Break into two separate films. Add explanation of Saturn's rings. Add rotation of Mars and Jupiter. Include recently discovered satellites; *viz.*, 13 instead of 11 satellites of Jupiter. Add animated drawings of recent theories of origin.

(4) *Exploring the Universe* (produced in 1936 by ERPI in collaboration with Walter Bartky, University of Chicago).

Commendable features: Solar motion, proper motions.

Questionable features: Multiple star systems are irrelevant. Too much emphasis on proper motions with too little on radial velocities. Misconceptions of periods of double stars can arise from speeded up animated diagrams. Animated diagram of galactic rotation does not follow Kepler's laws, and is not explained in terms of observations.

Suggestions: Break into two or more separate films. Spectroscopic binaries could be added, and the varying Doppler effect illustrated with a whistle on a rotating arm. The mass-luminosity law should be mentioned in connection with double stars.

Conclusions

Without claiming majority agreement, I have concluded from this survey that classroom films *can* be used effectively in astronomy courses as they are presently taught in the majority of U. S. colleges, regardless of the local teaching theories or techniques. The major objections to the use of films at the college level fall into two categories:

(1). Films now available are technically or scientifically imperfect: *e.g.*, they have poor narration, or poor lighting, or factual errors.

(2). Any film which presents the "whole story" in a complete form is too dogmatic for college students; instead of encouraging a student to think about the implications of average proper motions, for instance,

such a film tells the student exactly what to conclude about the solar motion.

The first of these objections can be readily eliminated by re-editing present films. The second is not supported by so many teachers; it is also in direct conflict with the economically necessary desire of film producers to make films suitable for the large market of high school general-science courses. The difficulty is that a classroom film serves quite a different purpose, when used as an adjunct to other teaching by a competent instructor, from that when it is used as a self-contained item in a high school general-science course.

Three suggestions can be made to overcome this difficulty: (a) By subsidies from universities, foundations or other agencies to make classroom films for the uneconomic college-level use only.

(b) To cut and re-edit present and future general-market films so that they may better serve the college-level purpose. Since the sound track is of minor cost compared to animation, present films might be issued in two or more editions, with different narration for college level and other levels. Cutting for college use should isolate presentations of phenomena (sun's motion along the ecliptic, lunar phases, eclipses, planetary motions in the sky, apparent motions of double stars, observed proper motions, motions of prominence on the sun, etc.), to be presented to students first. Representations of the more complex theoretical constructs (planetary orbits, solar motion, galactic rotation, etc.) might be presented later.

(c) To show present films in part, or without sound, or at the end of college class discussions or lectures, so that they serve as an illustration of what the instructor has developed and presented in his own manner. Thus, the part of a film which presents phenomena could be shown at the beginning of a lecture and the remainder at the end, or not at all.

Finally, it is concluded that, although there is some disagreement as to whether films can be as effective as models, the interest in additional classroom films in astronomy warrants the production of four or five new films on the topics listed on page 120 above. Parts of these might well be made from kinescope recordings of science television broadcasts, the major costs of which are born by the television sponsor whether or not films are made. Most of the materials are now available at one or other of the large U. S. observatories or universities.

Circulation of the list of films presently available (page 120 above) may help astronomy teachers acquire more films which can be used effectively in their classes.

Respectfully submitted,
THORNTON PAGE

Yerkes Observatory

EDITOR'S NOTE: A subcommittee has been appointed by the Teacher's Committee of the A.A.S. to study further the present classroom films in

astronomy and to write reviews for POPULAR ASTRONOMY. Miss Marjorie Williams, Smith College, is chairman, and Miss Alice Farnsworth of Mt. Holyoke College and Miss Marguerite Risley of Randolph-Macon College are members. Reviews by other astronomy teachers would also be welcome. Information concerning kinescope recordings of television broadcasts, other material which might be used in instructional films on astronomy, or any source of aid in producing new films, would be gratefully received by the subcommittee.

APPENDIX

Excerpts from reports* of the Instructional Film Research Program, The Pennsylvania State College.

I. Incidental Report No. 2: *Some Aspects of Learning from Films*, June 21, 1949.

"4. *Graphs and Photographs.* . . . Graphs and animations, except the most elementary animations that actually reproduce visual form, are not photographs and do not symbolize situations as they are ordinarily perceived. . . . Many instructional film producers seem to assume erroneously that the presentation of graphs on a screen somehow endows the graphs with the same communicative qualities possessed by photographs.

"As a matter of fact, an audience cannot understand a graph shown on a screen unless the audience can already read graphs and unless it already has an extensive knowledge of the relationship presented graphically. College students must be taught to read the charts and graphs. Putting these graphs in motion on a screen neither teaches them to read the graphs nor makes the relationships any clearer if the students have not learned to read them."

"C. *Language Symbolism.* Perhaps the three greatest abuses of language in instructional films are (a) the neglect to name things clearly and to name all the things the audience needs to have named; (b) the tendency to interpret relationships on a higher conceptual level of abstraction in language than is supported by the photographic presentation; and (c) the tendency to make too much use of language in narration or dialogue. . .

"Perhaps the greatest fault of language use in instructional films is the tendency to intellectualize the pictures too quickly in language, rather than to leave intellectualization to the audience after time for reflection and analysis. The film is so new as a medium of communication, and language is so old and has acquired such an unmerited instructional prestige, that instructional film-makers have yet to learn how to blend words and pictures, and how to use each most effectively, so as to increase the learning values of films."

"1. *Films Plus Books.* The evidence from investigations of learning from both film and books indicates that pupils learn a great deal more when they both watch movies and read books on the same subjects. One of the significant outcomes of the study of sound motion pictures in science teaching conducted by Rulon is that when subject matter is presented in both film and in text, there is a 55 per cent superiority in retained learning (after 3½ months) among those students who studied film and text over those who studied the text only. On materials presented in the text alone, the film-text group and the text-only group were equal in retained learning, although the text-only group was superior to the text-film group in immediate learning. If this finding can be generalized (and there is related evidence supporting such a generalization), it appears to be enormously significant of the fact that 'double exposure' in instructional media

*The reports quoted here by permission are progress reports, and their conclusions are tentative. They are available in photo-offset form from C. R. Carpenter, Director of the Instructional Film Research Program, The Pennsylvania State College, State College, Pennsylvania.

is a key to the efficiency of instruction. It is also significant, as Rulon himself pointed out, that such superiority as is immediately evident in those learnings derived from books only is lost over a period of time.

"2. *Films Plus Instructor Introductions.* This subject of 'double exposure' to instructional media is a fascinating and a fruitful one. We see its influence in the learning effect of a preliminary talk prior to a film showing. Not only is there an appreciable increase in learning of the material covered in the talk and in the film, but also in the material covered in film only. The effect of 'double exposure' appears to radiate beyond the material presented in both the talk and the film to influence the learning of material presented in the film only.

"While it is obvious that there are some things that cannot be efficiently communicated in films, as it is evident that words are weak carriers of other subjects, it begins to appear that prior analysis and good sense will reveal those areas in which films are good communicators and those in which words are good communicators. And so on for slides, and demonstrations, and maps, and the like. But it is to pioneering research that we must look for the answers on the questions of combined or integrated media, the increment in learning that comes through combination, and the optimal combinations."

"1. *Audience Ego Demands.* An audience-demand or expectancy exists among students for material which has the 'appearance of novelty'; otherwise, students feel that their learning ability has been underestimated. Students have certain ego-needs that arise out of their status as students. They need to feel that the teacher (film maker, pedagogue, or both) has a high estimate of their learning ability and that the material presented to be learned is commensurate with this ability level. They demand 'challenge' in their instruction. . .

"2. *Film-Habit Demands.* The context of instruction involves certain audience demands in the style of subject matter presentation. Among these demands are (a) specific factual information, (b) a logical arrangement of the content under major and minor headings, and (c) the presentation of this arrangement in such form that it permits notetaking."

"3. *Introjection and Motivation.* The major problem of instruction is not so much to show an audience how to do something or what something is like, but to stimulate the audience to want to do that something, and to accept the importance of that something."

"D. *'Closure' in the Use of Instructional Films.* . . . 'closure' is the term used to describe the compulsion to finish unfinished business, to complete a task. It is the filling in of missing items. It is the achievement of completeness.

"1. . . . an instructional film, to be instructional, should leave some things undone that need to be done, *i.e.*, should leave the audience with the feeling of necessity of further effort and personal responsibility for carrying the subject further, for putting it in practice, or for seeking additional light."

"2. *Instructional Films That Do Not Satisfy.* Instructional films are likely to be more instructional when they present their content in such a way that the audience is left with unfinished business, and has been provided with sufficient information so that it can bring this business to some kind of a satisfying conclusion."

II. Progress Report No. 11-12, March 1, to June 30, 1949.

"2. *Film production and audience characteristics.* It is . . . certain that for the production of effective instructional films, specific and relatively complete information on the . . . characteristics of the film's . . . audience should be . . . used by the . . . writers, directors, and editors who help produce the film. . . The following should be known: educational . . . level, level of maturity, previous knowledge and training in the subject matter of the film, patterns of . . . interests, probable level of motivations to learn from the film, probable need for information contained in the film, point in the training program when the information given by the film will be used, degree of verbal comprehension, level

of effective knowledge of technical terms and concepts, etc. Only by knowing these, and other facts about the training audience can those responsible for film production apply intelligently the principles of learning.

"*3. Limiting range of film objectives.* It is becoming increasingly clear that general films (films which either cover a wide range of subject matter or are 'angled' for . . . many educational levels), have of necessity low instructional efficacy. By contrast, films which aim limited subject matter at a specific trainee . . . of known characteristics are likely to be most effective.

"*4. Film variables: rate of development.* Evidence is accumulating to support the view that the rate of development of currently produced training films is generally too fast for the instruction of the *intended* . . . trainees. Present day pacing of informational films seems to be most appropriate to the dramatic or entertainment type films. Indications are that pacing should be varied to suit differences in the audiences' intelligence, educational levels, and their amounts of previous knowledge of the specific and related subject matters treated in the film. Pacing should also be varied to suit the difficulty of the subject matter itself."

"*5. Repetitive showings.* Facts are accumulating which point to the conclusion that repetitive showings of most training films will enhance the amount of learning. For most films now in use, two or three showings in all probability would be justified in terms of optimal learning gains. . . . Existing training films have a rapid rate of development; they are packed with material either in the pictures, commentary, or in both these streams of communicative events. Repeated showings make it possible for learners to grasp more of the content."

III. Special Report No. 1: Practical Principles Governing the Production and Utilization of Sound Motion Pictures, August 1, 1950.

I. Introduction

"More than 200 separate research studies of educational effects of motion pictures have been conducted to date in the United States and elsewhere. These studies have been analyzed and their results summarized and integrated.

"For the guidance of film sponsors, producers, distributors, and users, the results of research studies are here summarized under (1) values in instruction, (2) principles governing film influence, and (3) conclusions on improved effectiveness."

II. Values of Films in Instruction

"1. *People learn from films.* This applies to factual knowledge, motor skills, attitudes, opinions, and motivations. It probably applies to other educational objectives, such as appreciation and orientation.

"2. *The use of effective and appropriate films results in more learning in less time and better retention of what is learned.* This has been demonstrated repeatedly when films are compared with comparable reading materials or lecture presentations. The films, requiring less instructional time, result in more factual learning. Films in combination with other instructional materials are better than either alone. This holds for both immediate and delayed measures of learning effects. Occasionally, the audience has been found to remember more from a film after several weeks than after a few hours or a few days.

"3. *Instructional films stimulate other learning activities.* They stimulate such activities as voluntary reading, discussion, application, teamwork, and the like.

"4. *Films facilitate thinking and problem solving.* The evidence clearly indicates that the contribution of films is to comprehension and understanding, rather than pure rote memory. Carefully conducted research studies demonstrate that people taught with films are better able to apply their learning than people who have had no film instruction.

"5. *Films are equivalent to a good instructor in communicating facts or demonstrating procedures.* This means that films can be used exclusively for instruction when the instruction involves presenting facts or demonstrating procedures, and where face-to-face leadership is not required."

III. Principles Governing Film Influence

"1. *REINFORCEMENT: Films are of greatest influence when their content reinforces and extends previous knowledge, attitudes, and motivation; they are of least influence when previous knowledge is inadequate, and when the film content is antagonistic or contrary to existing attitudes and motivation.*

"A person can respond to a film only in terms of what he already knows, what he can do, how he feels, and what he wants. The film itself does not substantially change the person. It can, however, help to change his attitudes and opinions, his knowledge and skills.

"The influence of any one film is limited. The influence of several films is cumulative.

"The effects of any motion picture depend to a great extent on the reinforcing experiences preceding, following, or coincident with the actual film showing."

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"2. *SPECIFICITY: The influence of a motion picture is specific, not general.*"

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"3. *RELEVANCE: The influence of a motion picture increases as the content of the film is directly relevant to the audience reaction it is intended to influence.*"

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"Production time, facilities, and expense can be saved by omission of content and treatment irrelevant to the specific behaviors the film is intended to influence."

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"4. *AUDIENCE VARIABILITY: Reactions to a motion picture vary with film literacy, abstract intelligence, formal education, age, sex, previous experience in the subject, and prejudice or predisposition of the audience.*"

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"Perception and retention of film content reaches its peak in late teens and early adulthood, declines with middle age. . .

* * * * * *

"The more the audience knows about a subject, the more it learns from a film on the subject. The more films the trainees have seen, the more trainees learn from any film."

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"In a film intended for a general audience, the film should be sighted slightly below the average of intelligence and education, rather than above it. This will help those on the average and below it, will not hurt those above the average. When circumstances of use permit, two or more versions of a film, each appropriate to different audience levels, should be produced when there are wide differences in the intended audience."

"5. *PICTURE PRIMACY: The influence of the motion picture is primarily in the picture, secondarily in the accompanying language and/or music, and is relatively unaffected by 'slickness' of production.*

"Trainees learn more from the pictures than from the commentary. . . Language articulates discovery or alerts the audience to it. Appropriate music underscores mood. Color film has not been demonstrated as *generally* superior in instruction to black-and-white film. . .

"Too much talking (over 100 words a minute) interferes with learning from a film. Language (commentary, narration, and dialog) should be held to a minimum in a motion picture. 'Slickness' of technique is costly in production, not significant in instruction, and seldom noticed in screening."

"6. *PICTORIAL CONTEXT: Response to motion pictures is selective in terms of the familiarity and significance to the audience of the pictorial context in which the action takes place.*

"Not everything shown or said in a motion picture is seen or heard by the audience. Response to films is selective, not photographic. Scenes and sequences are seen and heard when the pictorial background is familiar and the action or object is significant to the audience. . .

"No matter what form or treatment is used in the film, important scenes and interpretations must be made to appear important to the audience.

"Light humor helps, slap-stick is likely to hurt instruction."

"7. *SUBJECTIVITY: Response to a motion picture is most intense, efficient and predictable when the pictorial content is subjective to the audience.*

* * * * * *

"Direct instructions and direct address to the audience are better than the third-person, passive voice."

"8. *RATE OF DEVELOPMENT: Rate of development influences the impact of a motion picture on its audience.*

"Where learning, rather than entertainment is involved, slow rather than rapid rate of development is necessary. The rate of learning of the audience is generally slower than the subject-matter expert thinks. Don't try to cover too much too quickly in any one film."

"9. *INSTRUCTIONAL TECHNIQUES: Instructional techniques built into the film, or applied by the instructor, substantially increase the instructional effectiveness of a film.*

"The following instructional techniques add significantly to the effectiveness of films:

1. Relevant summary of the subject content of the film.
2. Prior announcement of a check-up on learning from the film, such as a quiz.
3. Repeated film showings, and/or repetition *within a film.*
4. Audience participation (or practice) *during* or *following* a film showing.
5. Instructors trained in effective instructional techniques, and the necessity of their application to film use. . ."

"10. *INSTRUCTOR LEADERSHIP: The efficiency of learning performance of a group to whom a film or filmstrip is exhibited is influenced by the leadership of the instructor who uses the film or filmstrip, as well as by the effectiveness of the film or filmstrip itself.*

* * * * * *

"Films cannot substitute completely for the good instructor, particularly in situations where face-to-face leadership is required. Effective training of instructors is essential to greatest effectiveness of film instruction."

IV. Conclusions

"Four conclusions which apply to motion pictures in training, orientation, and information clearly emerge from this review of film research.

1. The educational effectiveness of films can be improved, but to do so steps must be taken *all along the line* from the origin of the film idea to the utilization of the film in instruction, and not simply at the production stage.

2. The effectiveness of films in instruction depends on the relationship of the film content to the audience and the context of their use, and not simply on the film itself.

3. Within the film, treatment of the content in terms of psychological and instructional principles governing audience reaction is of greatest importance. Film techniques involving special effects and elaborate musical scores are of minor importance.

4. Of all the devices of mass communication, motion pictures and their counterpart, television, are unquestionably the most powerful for instructional use."

Long-Focus Photographic Astrometry

By PETER VAN DE KAMP

(Continued from page 79)

CHAPTER III

Reduction of Photographic Plates. Dependences. Long-range Investigations

We now apply the long-focus photographic method to the study of the path of a star. The star may be under observation for parallax, in which case useful information may be obtained in a few years.[1,2,3,4] Or, the star may be under observation for orbital motion, and hence, a prolonged interval of time,—several decades, or even centuries,—may be necessary to obtain the required observational material. In all cases the path of the star is referred to and measured on a background of reference stars. The measured values must be properly adjusted or "reduced," so as to permit a precise analysis of the star's path; the reduction method will now be described.

1. *Scale and orientation effects on measured positions.*

The principal effects on the measured positions may be summarized as changes in scale and orientation, resulting from the following causes:

1. Observational:[5]
   a. Instrumental (measuring engine, telescope)
   b. Spherical (refraction, aberration)
2. Cosmic:[6] Proper motions of reference (and orientation) stars.

Accidental errors of the angle of orientation may be kept well below .0002 radians when we orient by star images. Only proper motions of the orientation stars may introduce a systematic effect; a yearly change in orientation of the order of .0001 is not excluded and its accumulation over many years might become serious. To avoid a progressive change in orientation and its effect on the measurements, the proper motions of the orientation stars should be sufficiently known so that they may be allowed for. Variations in scale due to changes in temperature and barometric pressure are negligible for the present purpose. The maximum scale effect due to aberration is a factor .0002, and its possible effect on parallax is negligible.

Because of the small angular extent of the long-focus plates the small changes in refraction and aberration may be considered as linear functions of the position of the star on the plate. Hence we need only consider differences in origin, scale, and orientation, when comparing the different plates of a series of observations of one and the same field. All that is necessary is to reduce the measurements by a linear transformation to a common origin, scale, and orientation.

The effect of plate tilt is generally negligible for long-focus instru-

ments. Let p and q be the rectangular coordinates of the base of the plate, *i.e.*, the location of the point of tangency with the celestial sphere relative to the intersection of the optical axis.[7] The resulting corrections are

$$px^2 + qxy \text{ in } x, \quad qy^2 + pxy \text{ in } y.$$

For an extreme x or y of 20′, and a value of 1′ for p and q, the quadratic terms in the above expressions would be only ″.002.

2. *Reduction of measurements to a standard frame.*

In order to permit a comparison of measured positions on different plates, a reduction is made to a *standard frame* as defined by the reference stars.[8] We use rectilinear coordinates closely oriented to the directions of right ascension and declination. Let X', Y' and x', y' be the measured positions of central and reference stars as recorded at the measuring machine. The zero point is arbitrary, the scale and orientation are close to that of the adopted standard frame given by the configuration of n reference stars. The coordinates of the standard frame shall be denoted by the subscript s; the positions

$$x_s, \ y_s$$

defining the standard frame of reference are relative to their mean position, *i.e.*,

$$[x_s] = [y_s] = 0. \tag{1}$$

3. *Plate constants.*

All measured positions can now be reduced to the scale, orientation, and origin of the reference frame

$$(x_s, \ y_s)$$

through *plate constants* a, b, and c, which are given by the linear equations of condition,

$$\begin{aligned} a_x x_s + b_x y_s + c_x &= x_s - x' \\ a_y x_s + b_y y_s + c_y &= y_s - y'. \end{aligned} \tag{2}$$

A least squares solution gives

$$\begin{aligned} a_x &= \frac{[y_s^2]\,[x_s(x_s - x')] - [x_s y_s]\,[y_s(x_s - x')]}{[x_s^2]\,[y_s^2] - [x_s y_s]^2} \\ b_x &= \frac{[x_s^2]\,[y_s(x_s - x')] - [x_s y_s]\,[x_s(x_s - x')]}{[x_s^2]\,[y_s^2] - [x_s y_s]^2} \\ c_x &= -\frac{[x']}{n} \end{aligned} \tag{3}$$

and similar expressions for

$$a_y, \ b_y, \text{ and } c_y.$$

For the central star the position X, Y reduced to the standard frame is given by

$$\begin{aligned} X &= X' + a_x X_o + b_x Y_o + c_x \\ Y &= Y' + a_y X_o + b_y X_o + c_y, \end{aligned} \tag{4}$$

where

$$X_o,\ Y_o$$

are values of X, Y rounded off to a sufficient number of significant figures. Thus the position

$$X_o,\ Y_o$$

is rigorously corrected for plate constants, while the rounding off leads to the neglect of the following quantities:

$$\begin{aligned} &a_x (X - X_o) + b_x (Y - Y_o) \ \ldots\ \text{in } x \\ &a_y (X - X_o) + b_y (Y - Y_o) \ \ldots\ \text{in } y. \end{aligned} \tag{5}$$

4. *Dependences. Dependence centers. Plate solutions.*

Schlesinger has shown that for the case of linear plate constants considerable time and insight may be gained by expressing the reduced position as an explicit linear function of the measured coordinates.[2,4,8] The necessary transformation is obtained by substituting (3) in (4), which leads to:

$$\begin{aligned} X &= X' + \left\{ \frac{X_o \{x_s [y_s^2] - y_s [x_s y_s]\} + Y_o \{y_s [x_s^2] - x_s [x_s y_s]\}}{[x_s^2] [y_s^2] - [x_s y_s]^2} (x_s - x') \right\} - \frac{[x']}{n} \\ Y &= Y' + \left\{ \frac{X_o \{x_s [y_s^2] - y_s [x_s y_s]\} + Y_o \{y_s [x_s^2] - x_s [x_s y_s]\}}{[x_s^2] [y_s^2] - [x_s y_s]^2} (y_s - y') \right\} - \frac{[y']}{n}. \end{aligned} \tag{6}$$

The resulting reduction statement, regardless of the zero-point of the measured coordinates, is therefore

$$\begin{aligned} X &= X' + [D_i (x_s - x')_i] \\ Y &= Y' + [D_i (y_s - y')_i], \end{aligned} \tag{7}$$

where

$$D_i = \frac{X_o \{x_{si} [y_s^2] - y_{si} [x_s y_s]\} + Y_o \{y_{si} [x_s^2] - x_{si} [x_s y_s]\}}{[x_s^2] [y_s^2] - [x_s y_s]^2} + \frac{1}{n}, \tag{8}$$

$i = 1, \ldots n$, are Schlesinger's *dependences*. In the plate-constant method X and Y are implicit functions of (x') and (y'); the dependence method provides a direct expression which greatly simplifies the reduction calculations.

It is obvious that $[D] = 1$, and, because of the least-squares procedure, that $[D^2]$ is a minimum.

The "dependence reductions" (7) may be written as follows:

$$\begin{aligned} X &= [Dx_s] + X' - [Dx'] \\ Y &= [Dy_s] + Y' - [Dy'], \end{aligned} \tag{9}$$

the calculations generally being carried to .0001 mm. The position

$$[Dx_c],\ [Dy_c]$$

defines a point close to the central star; it is called the *dependence center*; $[Dx']$, $[Dy']$ is the, measured, *dependence background*. The primed symbols in (9) refer to the measured coordinates, their zero-point is eliminated; the coordinates,

$$x_c,\ y_c,$$

used in the computation of the dependence center, however, refer to their mean.

The dependence method provides rigorous linear plate-constant reduction for the dependence center and leaves only a small segment uncorrected. This is the so-called *plate solution*, sometime called offset:

$$\begin{aligned} \xi &= X' - [Dx'] \\ \eta &= Y' - [Dy']. \end{aligned} \tag{10}$$

and it remains uncorrected to the amount given in (5). Theoretically the plate solutions should vanish for the position

$$X_a,\ Y_a$$

but because of the limited number of decimals in D small plate solutions are created also for this position. Because of their explicit use in the dependence reduction method, it is convenient to substitute the plate solution ξ, η in the reduced positions so that

$$\begin{aligned} X &= [Dx_c] + \xi \\ Y &= [Dy_c] + \eta. \end{aligned} \tag{11}$$

In general, if the plates are carefully oriented, the plate constants are factors less than .0002 and their effect on the plate solutions is well below the observational errors. If the uncorrected segments or plate solutions are kept sufficiently small, say about .2 to .3 mm., rigorous linear plate constant reduction is therefore obtained within the errors of observation for the duration of the dependence set. Hence a number of plates can be reduced with one set of dependences calculated for one position

$$X_a,\ Y_a$$

of the central star. For example, in the case of parallax determination extending over a few years only, all plates, as a rule, are reduced by one dependence set and the small changes of the position of the central star are expressed by the plate solutions.

The dependence method has another advantage; it reveals the significance, or weight of the different reference stars. The dependence method gives no information about the plate constants, which are eliminated; in general, however, the plate constants are of no particular interest.

5. *Change of dependences.*

There are problems such as conventional parallax determinations, in

which the path covered by the central star is small enough to be served by one set of dependences. As mentioned above, in this case the plate solutions as such, *i.e.*, the positions with respect to the dependence background of the reference stars, may be used and no further reduction is necessary. But in several problems it is necessary to use more than one dependence center, either because of appreciable change in the position of a central star due to proper motion, or because it is desired to study the relative position of two or more stars on the same plate which are widely separated. In all such cases a reduction to the origin of the standard frame commends itself.

For the case of appreciable proper motion of the central star successive dependence sets are so chosen that the dependence center is kept close to the central star. As before, the uncorrected segments, or plate solutions, ξ, η, are kept sufficiently small so that, through careful orientation mainly, rigorous linear plate constant reduction is obtained within the errors of observation for the duration of each dependence set. Since many measured positions are reduced by the same set of dependences, the economy of the dependence method is maintained, and it remains a desirable substitute for the plate-constant method.

In many long-focus problems (parallax, mass-ratio, perspective acceleration, perturbation) there is no obvious need for a knowledge of accurate positions of the reference stars. If, however, the position and proper motion of the central star, or stars, as such are of importance, the need for an accurate knowledge of the position and proper motion of the system of reference stars is ultimately necessary. The necessary data can be obtained by referring the limited number of reference stars to a more comprehensive group of stars, the material being spread over a sufficient time interval. In this case it still appears advisable to adopt the standard frame

$$(x_s,\ y_s);$$

an eventual reduction

$$(\Delta x_s,\ \Delta y_s)$$

to a more precise reference system is obtained by the addition of

$$[D\,\Delta x_s],\ [D\,\Delta y_s]$$

in formulae (9) or (11).

6. *Calculation of dependences.*

A set of dependences for an initial position

$$X_o,\ Y_o$$

and the standard frame,

$$(x_s,\ y_s),$$

may be computed by the linear formulae:

$$D_i = f_i\,X_o + g_i\,Y_o + 1/n. \tag{12}$$

Here

$$f_i = \frac{x_{si}\,[y_s^2] - y_{si}\,[x_s y_s]}{[x_s^2]\,[y_s^2] - [x_s y_s]^2} \quad \text{and} \quad g_i = \frac{y_{si}\,[x_s^2] - x_{si}\,[x_s y_s]}{[x_s^2]\,[y_s^2] - [x_s y_s]^2} \tag{13}$$

with the control equations:

$$[fx_s] = 1 \text{ and } [gy_s] = 1. \tag{14}$$

The quantities D_i are computed to an adequate number of decimals; since

$$[x_s] \text{ and } [y_s]$$

are rigorously zero, they must satisfy the equations

$$[D] = 1, \ [Dx_s] = X_o, \ [Dy_s] = Y_o. \tag{15}$$

The first equation must be rigorous in order to provide accurate elimination of the zero-point of the measured coordinates. The calculated dependence center

$$[Dx_s], \ [Dy_s]$$

must equal the position

$$X_o, \ Y_o$$

within the errors due to rounding off the dependences.

In practice it will be found convenient to adopt for

$$X_o, \ Y_o$$

the position in a certain year. For any other year the dependences can thus be easily computed through the use of their annual variations ΔD, which are given by

$$\Delta D_i = f_i \mu_X + g_i \mu_Y. \tag{16}$$

Here

$$\mu_X, \ \mu_Y$$

are the rectangular components of the yearly proper motion of the central star; the control equations are:

$$[\Delta D] = 0, \ [\Delta D \, x_s] = \mu_X, \ [\Delta D \, y_s] = \mu_Y. \tag{17}$$

By means of these formulae an ephemeris for both dependences and dependence centers is easily computed.[9] For plates taken with the twenty-four-inch Sproul refractor (scale 1 mm = 18".87),

$$x_s, \ y_s$$

are used to .01 mm; this means that the scale and orientation errors of the adopted standard frame are usually below a factor .0001. Using two decimals in

$$X_o, \ Y_o$$

the dependences are computed to four decimals, but rounded off to three, always taking care that their sum shall rigorously equal unity. The dependence centers are computed to .0001 mm.

The rounding off to three places in the dependences leads to values of the plate solutions which are generally not over .1 mm near the dependence epoch. By spacing the dependence centers not more than about .50 mm (nearly 10") apart in each coordinate, the solutions seldom exceed .25 mm and errors due to extreme orientation (and scale) constants are rarely above .00005 mm.

7. *Choice of configuration of reference stars.*

The choice of reference stars is guided by various considerations.[10] It depends of course on the exposure time and limitations due to required magnitude compensation. In any long-term astrometric problem it is important to study carefully any possible choice of reference stars, so that one will not be faced with early obsolescence, but will have a well-planned foundation for the present and possibly future configurations of reference stars. For a star of appreciable proper motion which is to be observed over a long interval, one should choose a sufficiently large grouping (avoiding stars near the edge of the plate), so that the same reference system may serve for as long a time as possible. Limited by the size of the telescopic field and the photographic plate, any configuration has only a limited period within which maximum usefulness is reached. It is advisable to choose a configuration which the central star has recently entered, so that long use can be made of the reference system. The importance of a reference star in a long-range problem should be judged not only by its present dependence value but by the annual dependence variation as well. The advantage of having one long-range reference system more than offsets the possible temporary occurrence of negative dependences at the beginning and end of its period of usefulness.

Graphical methods are very useful for an initial exploration and evaluation of the dependences of different configurations of reference stars;[11,12,13] they are particularly effective for three-star combinations.

For a central star with considerable proper motion the effect of each reference star on its reduced position changes with the time; thus secular effects due to magnitude, color, and proper motion are introduced. The first two are kept at a minimum by limiting the range in magnitude and spectrum for the reference stars; the dispersion effects can be minimized by photography in the longer wave-lengths. In long-range astrometric problems the effect of the proper motion of the reference stars becomes important.[9] This particular effect will be studied in Chapter VII.

8. *Positional accuracy.*

The chief consequence of the central star's motion is the varying accuracy of its geometrical fixation due to its changed location within the configuration.[10] As we shall see in Chapter IV, greatest astrometric accuracy is reached by having a small configuration of reference stars. We shall neglect the possible variation in intrinsic positional accuracy of each reference star with its location on the photographic plate. The geometrical accuracy of the reduced position of the central star depends on the distribution of the dependences for the reference stars. In case of a central star of appreciable proper motion these dependences change and result in a corresponding change in accuracy for the changing dependence background. In that case, the error squared, or *inverse weight*,

of the position measured on the dependence background is proportional to

$$1 + [D^2]. \tag{18}$$

Writing

$$D_t = D_o + t\,[\Delta D]$$

this error function becomes

$$1 + [D_o^2] + 2t\,[D_o\,\Delta D] + t^2\,[\Delta D^2], \tag{19}$$

reaching a minimum value for

$$t_m = -\,[D_o\,\Delta D]/[\Delta D^2]. \tag{20}$$

Calling the dependences at this epoch D_m, the error function at any other time is given by

$$1 + [D_m^2] + (t - t_m)^2\,[\Delta D^2]. \tag{21}$$

For any investigation spread over a limited time interval, greatest accuracy is maintained if the position of greatest dependence accuracy is reached about the middle of that interval. If the interval is not more than a few decades it is generally not difficult to find an appropriate configuration for which the dependences vary not too much over the interval and would in any case remain positive.

The absolute minimum value of $[D^2]$ in the configuration

$$(x_c,\ y_c)$$

exists for the origin defined by

$$[x_c] = [y_c] = 0,$$

where each of the dependences equals $1/n$. For any central star, therefore, to insure a satisfactorily small $[D_m^2]$, it is important to choose a configuration whose origin will not lie too far off the path of the star.

As to the number of reference stars, even for a central star at the origin, the accuracy does not increase much with the number of reference stars. This is illustrated in Table I. Considering the extra work involved, not much accuracy is generally gained by using more than 4 reference stars.

TABLE I

Accuracy on backgrounds of 3 and more stars (equal dependences).

n	Inverse weight $1 + [D^2]$	Relative error
3	1.333	1.031
4	1.250	1.000
5	1.200	.981
6	1.167	.967
.	.	.
.	.	.
.	.	.
∞	1.000	.895

In case of a limited problem such as a conventional parallax determination, nothing therefore is more desirable than a configuration limited in number of stars, and in areal extent, and with approximately equal dependences.

9. *Long-range problems. Transition from one configuration to another. Addition of reference star.*

When planning measurements for a region which is to be observed for a long time, one should make a survey of potential configurations. The proper motion of the central star should be known, so that its future path can be traced with sufficient accuracy. After considerations of magnitude compensation and exposure time, a few possible configurations are likely to be found, all of them satisfying the condition that at some time in the future the path of the central star will pass close to the center of the configuration. For a short-term problem, it may be desirable to use a relatively small configuration with the corresponding advantage of increased astrometric accuracy. Even in this case, however, it is wise to provide for a possible extension toward a long-range problem. This could of course be done by starting with a larger "long-range" configuration, even though its positional accuracy may be less. An alternative approach is to make a transition from a smaller to a larger configuration whenever future developments warrant such procedure.[10,14,15]

The addition of a reference star always leads to an increase in geometric accuracy, since it leads to a new distribution of the dependences, for which $|D^2|$ represents the least-squares minimum. This minimum value equals the old value if the dependence of the additional star is zero; if not, it must be smaller, even though a negative dependence for another star or stars may have appeared. The addition of another reference star might be of little or no value at present, as would be demonstrated by a small or even negative dependence value. The eventual transition to a reference system involving the inclusion of one additional star is most conveniently carried out about the time of vanishing dependence value for that star. The useful procedure is to realize the potential future importance of such a star, but for reasons of economy to refrain from measuring this star until its dependence attains an appreciably positive value. By measuring and reducing a sufficient number of common backgrounds at that time, any reductions of earlier plates to the new frame may be evaluated with adequate accuracy.

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(To be continued)

Galileo, the Astronomer*†

By GEORGIO ABETTI

Speaking of Galileo and of the other great men of his time, famous in science, we must remember that it was the time when by their merit the "experimental method" had its birth and rapid development in Europe, starting from the Italian universities and schools.

The old philosophy of the Greeks was certainly not to be despised, but new methods, new conceptions, experimenting had to be done towards the new philosophy, the *philosophia naturalis*, that is, what we call today "science." Science, today, is divided into hundreds of branches and specialties, while in those times, when nearly everything was yet to be done in the experimental field, a man, like Leonardo da Vinci, for instance, went from botany to anatomy, to architecture, in the various manifestations of his great genius.

Another thing we must keep in mind, when we consider and study the life of Galileo. We must remember the conditions of life in the sixteenth and seventeenth centuries with the traditions, habits, and fear that new ideas could bring revolution and changes which would not be agreeable to the powers dominating in that epoch.

First a student of medicine at the University of Pisa to please his father, Galileo soon was attracted by the physical sciences and began the study and experiments on falling bodies, dynamics, strength of materials, which later in his last years were completed and concluded in the "Dialogue of the two New Sciences."

Appointed as lecturer at the University of Pisa, the restrictions imposed upon the freedom of teaching in that institution caused him some difficulty with his colleagues, so that he was glad to accept the chair of astronomy at the University of Padua. About 1597 he wrote to Kepler, then in Graz, that he was a convinced "Copernican," and, although he did not dare to teach openly the new theories and doctrines, he certainly had more freedom than in Tuscany.

The new star which appeared in 1604 gave him the opportunity to make probably the first celestial observations that he ever had occasion to make with direct vision and without optical instruments. Everybody was very excited by this unexpected celestial phenomenon, which was believed, as usual at that time, to be connected with human affairs. Galileo was compelled to give at the University of Padua three lectures on this subject which were attended by numerous students. He proved among other things that the star did not show any parallax, that therefore it was very distant as were the other stars.

In 1609, as is well konwn, Galileo constructed by himself a telescope and soon after made astronomical discoveries of great importance which

*An address given before the Cleveland Astronomical Society on October 20, 1950.

†Eleventh paper in the series "Papers on Historical Astronomy."

he described immediately in Latin in a pamphlet published in Venice in 1610 and dedicated to Cosimo II of the Medici house.

The *Sidereus Nuncius* has a long title: "Sidereal Messenger in which the modern observations carried out by means of a new glass on the face of the moon, the milky way and the nebulous stars and which announces the new discoveries of innumerable fixed stars, as well as four planets never seen before, called after the Medici. Truly great are the things which in this small treatise I propose shall be seen and contemplated by investigators of nature. Great, I say, the novelties never heard of before in past centuries and the instrument with which they are manifested to our senses. It certainly is a great thing to add other innumerable stars to the number of fixed stars, which, up to the present age, we have been able to discern with our natural visual faculties and to expose openly, to view a number over ten times greater than that which was up to now known and observed."

Probably the greatest surprise which struck Galileo, when he directed his telescope to the sky, was to see "innumerable fixed stars" in addition to those seen up to that time with the naked eye. With this human instrument, in fact, stars down to the 6th magnitude are seen; with his small and imperfect telescope, Galileo could reach the 9th magnitude and resolve into clusters of stars some nebulosities of the Milky Way. The high mountain chains of the moon, which appear dim on the side turned away from the sun, but bright on the other side; the possibility of determining their heights, which he estimated to be at least four times as great as the terrestrial ones, are among the first discoveries of Galileo. He also observed the constellation of Orion and the Pleiades, of which he drew charts, and the nebulae believed to be clusters of stars not resolved by his telescope.

In the month of January, 1610, Jupiter being in favorable position to be observed, Galileo saw the major planet surrounded by three small stars. As in several books the reproduction of a famous page, written by Galileo at the time of his discovery, is given but generally not the translation of it from the Italian, we wish to give it here:[1]

"On January 7, 1610, Jupiter was seen with the cannon (the telescope), with three fixed stars, two to the east and one to the west, not one of which could be seen without the telescope. On the 8th the stars were all three on the west. The motion was therefore direct and not retrograde as the computers indicated. On the 9th it was cloudy. On the 10th the planet and stars were seen with two stars to the east, that is, the planet was in conjunction with the more western star, so that we may believe that this star was occulted. On the 11th again two stars were to the east and the star nearer to Jupiter was half as bright as the other and very near it, while on the other evenings all three of the

[1] Galileo's Manuscripts in the National Library in Florence (V. 3, Pt. 2, of the National Edition of the Works of Galileo Galilei, p. 427). See also, G. Abetti, "Storie dell' Astronomica," p. 65, Firenze, 1949.

stars were of the same magnitude and equally distant. Therefore it appears that there are around Jupiter three moving stars (*stelle erranti* = planets), which no one has ever seen until the present time. On the 12th the configuration showed one to the east and one to the west. The western star was a little less bright than the eastern one, and Jupiter was in the middle, about a diameter distant from the two stars; probably there was a third very small star very near to Jupiter on the eastern side; certainly it was there, as I could see with more diligent observation when the night became darker. On the 13th, having very well fixed the telescope, it was possible to see very near to Jupiter 4 stars, one to the east and three to the west, all of the same magnitude." . .

We may remember that the small telescope used by Galileo had magnifications ranging from 10 to 20 with resolving power about 10″. The field was very limited and the chromatic aberration of the simple objective lens considerable, so that we can see how difficult it must have been for him to recognize the satellites one from the other and to determine their periods of revolution around the planet.

These first discoveries gave rise to great discussions and by some, not a few, were not believed. Kepler himself, reading the *Sidereus Nuncius* but having no telescope to verify the presence of the Medici planets, expressed his doubts that Jupiter should have four moons, while the earth, such an important body, had only one, also considering that on Jupiter there are probably no human beings to observe the great spectacle of four moons going around the planet!

The problem of the determination of longitudes in general, but especially at sea, was outstanding at Galileo's time. The General States of Holland had offered a prize of 25,000 florins to anyone who could solve the problem in one way or another. Soon it occured to Galileo that the times of the periodical disappearing or appearing of the satellites, behind or in front of Jupiter, could offer a good method for the determination of longitude. The idea was good, but for a practical application it was necessary to know, with fairly good precision, the times of the satellites' eclipses in terms of the zero meridian, and some other means to determine the local times of the same eclipses. Galileo tried hard to compute tables of the motions of the satellites, but this was possible only in later years when G. B. Cassini, professor of astronomy at the University of Bologna and later director of the Paris Observatory, issued the *Ephemerides Bononienses Mediceorum Siderum*. Portable clocks were constructed only many years after Galileo. In the hope of issuing good ephemerides he was planning to use the telescope with an attachment to the head of the observer, so as to be able to follow the movements of the ship. As timekeeper he suggested the use of a pendulum. In making these proposals he excuses himself by saying that he had no practice in navigation.

The small enlargement available in his telescope did not permit him to discover the real shape of Saturn's rings. With the well-known

anagram he announced that Saturn appeared as a three-body object, the central disc being surrounded by two smaller ones. Later on, in a remarkable way, he made predictions of the disappearance and new appearance of the two small bodies which he believed were accompanying Saturn.

Discussing with his disciple, Don Benedetto Castelli, the motion of Venus around the sun, as required by the Copernican system, he was aware that Venus must present phases like the moon. His observations proved not only this fact, but he could draw the crescent of Venus and the greatly different apparent sizes of the disc in the various positions of its orbit. With another famous anagram the discovery was announced by Galileo to Giuliano dei Medici, then ambassador of the Medici in Prague.

The sunspots, seen by Galileo in 1611, were not announced by him officially at once as the other discoveries were, probably because he wanted to be sure about their nature. As a matter of fact, spots were seen with the naked-eye long before Galileo. At the time of Charlemagne (about 800 A.D.) it is reported that in France for eight consecutive days a dark spot was seen on the sun's disc, believed to be the planet Mercury. Galileo declared this a great mistake asserting that Mercury cannot stay projected on the sun more than seven hours.

In the "Aristotelian" conception of the perfection of celestial bodies it was difficult to admit the existence of spots on the sun. Galileo was the first to understand their true nature. In 1612 in an address to the Grand Duke of Tuscany (Cosimo II of the Medici house) he said: "Repeated observations have finally convinced me that these spots are substances on the surface of the solar body, where they are continuously produced and where they are also dissolved, some in shorter and others in longer periods. And by the rotation of the sun, which completes its period in about a lunar month, they are carried round the sun; an occurrence important in itself and still more for its significance."

Galileo made a precise photometric measure of their intensity, observing that sunspots are less dark than the darker regions of the moon, at the time of the full moon, their apparent darkness being due to the great luminosity of the sun-photosphere; he noted also that spots are confined to the equatorial zones of the sun, between 30° of latitude north and 30° south.

In 1612, while guest of his friend the Duke Filippo Salviati at his *villa delle Selve* at Signa near Florence, he discovered another interesting phenomenon told about by Salviati himself, one of the interlocutors of the famous "Dialogue of the two Principal Systems of the World," in the third "giornata" (day) of the Dialogue. While Galileo (the "Accademico Linceo" of the Dialogue) was guest of Salviati at the latter's villa, it happened that both observed a spot with a very definite umbra of large size. They were able to follow it on its apparent motion

across the solar disc, and they noticed that the path of the spot was not straight, but curved.

Then, as they continued their observations, one day, Salviati remarks that it came to the mind of "our Accademico" (Galileo), that a "great consequence" could be derived from this phenomenon. As usual, Salviati very clearly and with extraordinary skill explains the matter to the other interlocutors: Gianfrancesco Sagredo and Simplicio.

The sun should be placed at the center of the ecliptic, rotating on its axis, which is inclined at a certain angle to the ecliptic itself; and the earth should also rotate on its axis, inclined at another angle to the plane of the ecliptic, and on the ecliptic around the Sun. Sagredo finds the explanation a little complicated, but he wisely states that he will be able to understand better the matter considering the phenomenon with the aid of a celestial globe on which he could trace the ecliptic, the solar equator, and the terrestrial equator.

Simplicio instead admits that he had not understood at all the arguments of the *Accademico* explained by Salviati and moreover, quoting Aristotle and Ptolemy obstinately, finds that it is not necessary to believe in the Copernican system to explain this new phenomenon, because it is possible with the relativity of motion to refer all the observed facts to the sun moving along the ecliptic. "If you do not demonstrate first, he says, that the observed facts cannot be explained, making the sun move and the earth fixed, I will never change my opinion to believe that the sun moves and the earth is fixed."

Many still did not believe in the existence of sunspots and very lively were the discussions, so that, to make things clear, Galileo, in 1613, wrote another pamphlet "History and demonstrations of the sunspots and their accidents" which was published by the Academy of the Lincei in Rome. In consequence of these great discoveries Galileo was appointed by the Grand Duke of Tuscany as his first mathematician and philosopher, professor at the University of Pisa without teaching duties. As soon as he was in Florence the reaction, on the part of those who were afraid that the new discoveries and ideas of Galileo might have a bad influence, especially in regard to religious dogma, broke out in the form of attacks against Galileo from the pulpit of Santa Maria Novella in Florence. Eventually the relations between faith and science were discussed in the circles of the Medici court in the presence of the Dowager Grand Duchess Christine of Lorraine. Galileo, who knew very well this problem and was not present at the discussion, had occasion to write a famous letter to the Grand Duchess, which is a beautiful statement of how religion and science are not in contrast but on the contrary may work together for the benefit of humanity. Galileo closes his letter with this humorous statement: "How can we affirm that the holding of one opinion or another is so necessary, so that one is *de Fide* (to be believed on faith) and another is erroneous? Can there be an heretical opinion about a matter which has no concern with the health

of the soul? I would here repeat what I heard from an exalted ecclesiastical personage, that is that the Holy Spirit intended to teach us to go to heaven and not how the heavens go."

All the efforts of Galileo, after his astronomical discoveries and researches, were directed to explain and prove that the Copernican system had to be accepted in preference to the Ptolemaic system. So he set himself to write the famous book which brought to him so much trouble: The "Dialogue on the two Principal Systems of the World. An immense conception full of philosophy, astronomy, and geometry, where in meetings of four days the two principal systems of the world, the Ptolemaic and the Copernican, are discussed and the philosophical and natural arguments, as much for the one side as for the other, are impartially pointed out." It was impossible for Galileo to prove with his astronomical discoveries that the position of the sun had to be in the center of the solar system, because the Ptolemaic system would explain as well the relative motion of the sun and planets. Galileo thought that the flux and reflux, that is the flood and ebb tides of the sea, were due to the combined rotations of the earth around the sun and around itself and so important he believed this wrong idea, that he wanted to give to his book the title: "Dialogue of flux and reflux." Friends persuaded him not to do this, but the error of Galileo, who did not believe in the action of the moon and sun on the water masses of the earth, remains in the Dialogue and no other proof was available to persuade Simplicio to believe in the Copernican system.

In the last years of his life, though in his confinement at Arcetri near Florence he was not permitted to deal with matters of the universe, he speaks of the greatness of astronomical studies and foresees with his acute mind the enormous future efforts of men to study the number, distribution, and constitution of the stars.

In 1638, four years before his death, from Arcetri, being already completely blind, he wrote to his dear friend Elia Diodati:

"Alas my Lord, Galileo your dear friend and servant has been for a month totally and incurably blind. Think, my Lord of my afflictions when I consider that sky, that world, that Universe, which I, with my remarkable observations and clear demonstrations have enlarged a hundred and a thousandfold, beyond what was universally seen by the learned of all past centuries, are now so shrunk and limited to me that they are no greater than the space occupied by my person."

Arcetri—Florence, Italy.

Visual Observations of Nova Scorpii 1950

By DOMINGO TABOADA*

On August 9, 1950, Sr. Guillermo Haro announced to me his discovery of Nova Scorpii 1950. Two days later Harvard announced this discovery in card No. 1091 (August 11, 1950).

The magnitudes were determined with the 4-inch Zeiss refractor of my own Observatory in Puebla, Pue., México, by the method of comparison, using the stars of the Harvard card 1741*35*.[1]

Table I, column 1 shows the date; column 2 gives the date in Julian days, and column 3 shows the observed visual magnitude.

TABLE I

Date	J.D.	Mag.	Date	J.D.	Mag.
August 9	2,433,503.7	8.3	August 18	2,433,512.7	10.0
August 10	2,433,504.7	8.5	August 19	2,433,513.7	10.3
August 11	2,433,505.7	8.3	August 20	2,433,514.7	10.5
August 11	2,433,505.8	8.5	August 20	2,433,514.7	10.5
August 12	2,433,506.7	8.5	August 21	2,433,515.7	10.7
August 13	2,433,507.7	8.6	August 22	2,433,516	
August 14	2,433,508.7	8.7	August 23	2,433,517.7	11.2
August 15	2,433,509.7	9.0	August 24	2,433,518.7	11.5
August 16	2,433,510.7	9.3	August 25	2,433,519.7	11.7
August 17	2,433,511.7	9.6	August 26	2,433,520.7	12.1

Fig. 1 gives the light curve corresponding to these magnitudes and

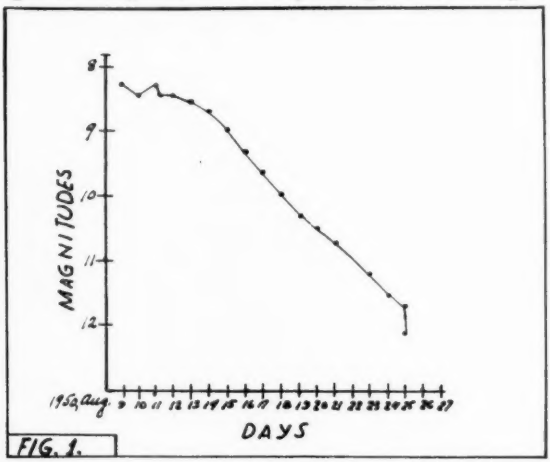

FIG. 1.

from this curve the Nova seems to be like Nova Lacertae 1936, or Nova Cygni 1920. William C. Braun[2] observed this object at magnitude 18 or fainter.

*Member of the A.A.V.S.O.

[1] Belonging to variable SV Scorpii.

[2] Popular Astronomy, Vol. LVIII, No. 8, p. 395, October, 1950.

Contributions of the Meteoritical Society

Edited by FREDERICK C. LEONARD
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The Odessa, Texas, Siderite (ECN = + 1025,318)*

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ABSTRACT

This paper presents certain historical facts relating to the discovery of meteorites in the neighborhood of the Odessa, Texas, Meteorite Crater; a discussion of the distribution and other characteristics of the meteoritic materials so far recovered by surface and subsurface search at that crater; a detailed mineralogical and metallographic study of the metallic phase of the meteorite; and chemical and radiochemical analyses of the sideritic material. The results of the investigation, insofar as they relate to the unaltered nickel-iron, are consonant with the classification of Odessa as a coarse octahedrite (Og). Two (2) figures and 2 tables are given.

INTRODUCTION

The first reported find of an iron meteorite in the neighborhood of the topographic feature near Odessa, Texas, later to be recognized as a meteorite crater, was made by Mr. Arthur B. Bibbins of Baltimore, Maryland, in 1921. Dr. G. P. Merrill's (1922)[9] analysis of the material found by Bibbins revealed its meteoritic nature. Bibbins' subsequently published communication (1926)[2] on the siderite and the curious depression in the level limestone plain near which the mass of metal was found aroused the interest of Mr. D. M. Barringer, Jr., a son of the geologist who first correctly diagnosed the origin of the great crater near Canyon Diablo, Arizona, since called the Barringer Meteorite Crater. In June, 1926, Mr. D. M. Barringer, Jr., visited the depression, and not only found several additional small fragments of nickel-iron, but also reached and shortly thereafter published the conclusion that the Odessa Crater had its origin in meteoritic impact.[1]

In the years between 1926 and 1939, an occasional visitor to the Odessa area searched for meteorites with success, but the gleanings were negligible in comparison with the rich harvest collected from the area about the Barringer Meteorite Crater of Arizona during the first years after its meteoritic origin became known. This dearth of surface meteorites at one time threatened to place in jeopardy the entire program for the systematic exploration of the Odessa Crater which was initiated by the University of Texas and which employed W.P.A. labor. On September 13, 1939, when the First Ohio State University Meteorite

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Expedition stopped off at the Odessa Crater on its return journey from the Canyon Diablo area to Columbus, Ohio, W.P.A. squads working under the direction of Professor W. D. Mateer had been excavating the Odessa Crater and conducting surface searches in the region surrounding it for 3 weeks, yet the sum total of unaltered meteoritic material found by the laborers consisted of a small fragment weighing less than a pound! The failure to discover meteorites had seriously affected the scientific value of the well-conceived exploratory program of the University of Texas. Fortunately for the Odessa Crater Project, Professor Mateer enlisted the aid of the Ohio State University Expedition in carrying out a hasty but eminently successful search of the area just south and west of the Crater with the meteorite detectors developed at the Ohio State University.[6] In sweeps totaling 12 hours, 13 siderites and a large number of "shale balls" were found. The solid irons discovered ranged in weight from a few ounces to the remarkable "accordion meteorite," estimated to weigh at least 300 pounds, which had penetrated approximately 3 feet into the solid rock underlying the soil layer outside the Crater.§

These recoveries established once and for all time that "Bibbins' depression" was a genuine meteorite crater, and rendered certain the completion of the systematic exploratory program initiated by the University of Texas. Furthermore, the data on meteoritic masses *versus* depth of penetration, accumulated during the excavation of the meteorites located by the use of the meteorite detectors at Odessa, first disclosed that 2 categories of meteorites may lie buried about a meteorite crater: (1) the "fragments" thrown out in parabolic paths by the explosion that produced the crater; and (2) the "outrides," or small companion meteorites, which accompanied the main mass in its orbital motion. Irrespective of the weight of the "fragments," they were found buried at almost the same depth, namely, 7 inches, below the present surface of the ground at Odessa. On the contrary, the depth of penetration of the "outriders" was found to be given by a linear function of the cube root of the mass as predicted by the penetration theory developed by LaPaz.[5,7]

Altho a very large amount of Odessa material, oxidized and unaltered, has become available for examination as a result of the instrumental surveys and excavations just described, little has been published on the chemical composition and mineralogical structure of the Odessa meteorites since Merrill's pioneer paper of 1922,[9] and only one paper has appeared devoted to a similar analytic study of the Odessa oxides (Buddhue, 1939).[4] Furthermore, little attention seems to have been given to the rock forms present at various depths in and around the Odessa Crater, which were produced by the metamorphic action of the

§ *V.* Fig. 74, p. 147, in Fletcher G. Watson's *Between the Planets*, Blakiston, Philadelphia, 1941. The weight of the accordion meteorite should have been given as 130 kg., *not* 13 kg.! *V.* also Fig. 3, *C.S.R.M.*, **3**, 15; *P. A.*, **50**, 163, 1942.

heat and pressure incident to the impact, not only of the main mass but also of the "outriders" of the Odessa fall. In our laboratories at the University of New Mexico, detailed studies of all 3 of the categories of meteoritic material just enumerated are being made. It is the purpose of the present paper to report a mineralogical, chemical, and metallographic study of the metallic phase.

Macroscopic Examination

The specimen of the Odessa siderite examined in this report is a fine example of the so-called jaw-shaped or gnathoid meteorites (Figs. 1A & 1B). This specimen weighs 1295 gm. and has a length of 148

Fig. 1
Two Views of the Odessa, Texas, Siderite

mm., a width of 84 mm., and a maximum thickness of 35 mm. Viewed from the side (Fig. 1B), this nickel-iron has a crudely concavo-convex lenticular appearance, so that, altogether, it looks not unlike an ancient hand implement. The surface of this siderite is comparatively smooth with only a few suggestions of shallow piezoglyphs. The color on the convex side is black to dark brown, and the surface shows little friable material. The color on the concave side is, however, reddish-brown, and the material flakes off rather easily. Presumably this latter surface is a fracture surface along which this specimen was attached to a larger mass of the Odessa meteorite. We may speculate that the rounding at the "handle" of the meteorite (Fig. 1A) was due to the weathering out of troilite nodules.

Microscopic Examination

A slice of the Odessa siderite was mounted in bakelite, polished, etched with nital for 15 seconds, and studied with the metallographic microscope. The structure, as revealed on the etched surface, is that of a coarse octahedrite (subclass = Og), inasmuch as most of the kamacite lamellae fall in the range of 1.5-2.0 mm. in thickness. The bands cross one another in 2, 3, or 4 directions.

The external zone of alteration is vanishingly small for the most part, reaching a maximum depth of only 0.1 mm. The interior of the siderite is entirely free from alteration. Unquestionably the meteorite did not endure prolonged heating during its flight thru the atmosphere; this conclusion may be inferred not only from the shallowness of the zone of alteration but also from the unaltered appearance of the kamacite, taenite, and plessite.

The meteoritic components present are kamacite, taenite, plessite, schreibersite, and lawrencite. Most of the meteorite is composed of broad bands of granular kamacite exhibiting several sets of well-developed Neumann lines. The granular nature of the kamacite, and poorly-developed Neumann lines are shown in Fig. 2.

Taenite occurs as very narrow, usually highly irregular, bands, which either bound the kamacite lamellae or occur around and in the plessite

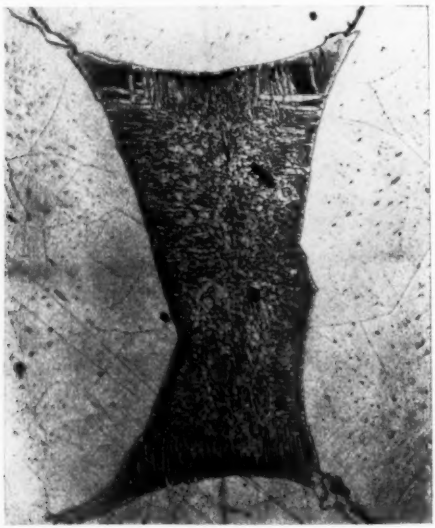

Fig. 2

A plessite field with predominant light plessite and subordinate dark plessite. The field is bounded by taenite and inclosed in a matrix of granular kamacite. Small, well-developed, rhomb-shaped, and elongate rhabdites are poikilitic in the kamacite. Poorly-developed Neumann lines may be observed. Odessa siderite. Nital, 15 sec. × 40.

fields. The coarsest types of light plessite show skeletal growths of taenite—the so-called "comb" arrangement, parallel to one or more of the surrounding octahedral planes. In this arrangement the taenite bands are thickest at the edge of the plessite field and thin towards the center of the plessite. Taenite, bounding both the plessite field and the kamacite lamellae within the plessite field, is shown in Fig. 2.

Several fairly large fields of plessite are present in the polished section—one such field reaches dimensions of 3×1.2 mm.—and many smaller fields are present. The plessite ranges from light, or normal, in which long, oriented kamacite bands are bounded by finer taenite, to dense, or dark, in which minute taenite particles are embedded in a matrix of fine kamacite. Both types are shown in Fig. 2, and the proportion of light to dark plessite in this figure reflects the proportion of the two types in the meteorite; that is, the light plessite predominates. One plessite area was noted with a Widmanstätten structure. Lord (1941) observed the same structure, and speculated that such "'plessite' patterns have been formed by heating and cooling, subsequent to the original formation."[8]

Schreibersite is uniformly, tho not abundantly, present, occurring usually in the kamacite plates as small crystals with a rhombic habit or with an elongate, distorted habit (Fig. 2). That this material is schreibersite and not cohenite was shown by the negative reaction to boiling, alkaline sodium picrate. One large inclusion of schreibersite—5.5×1.7 mm. in dimensions—is in the polished section. This inclusion is bounded by taenite, and the taenite contains rounded inclusions of kamacite. This schreibersite has a typical metallic appearance with a slightly yellowish tinge; it is harder than a needle, brittle, usually cracked, and apparently localized. The bounding taenite has, superficially, much the same physical appearance as has the schreibersite, tho the former is somewhat whiter and, of course, softer. The taenite has the same cracked appearance, however, and, in some instances, cracks are continuous thru both the taenite and the schreibersite. One gets the impression that this large grain of schreibersite represents a residual concentration of liquid nickel-iron phosphide, which was the last material to crystallize. The pressure that resulted from the crystallization of this residual liquid developed cracks in the bounding meteoritic material.

Several days after the specimen was polished, a number of brown, dendritic, or arborescent growths appeared along the boundaries separating kamacite grains. This dendritic growth is the mineral goethite, or, as it is more commonly called, limonite, a hydrated ferric oxide. The growth reflects the presence of lawrencite in the meteorite.

No other accessory meteoritic components were observed in the section.

Analyses

Chemical Analysis of the Odessa Siderite.—A small sample was cut from the Odessa siderite, etched, and examined carefully with a micro-

scope to make certain that the section for chemical analysis was typical of the meteorite. The chemical analysis of the meteorite is shown in Table 1, column (1). In Table 1, column (2) is given the corresponding analysis reported by Merrill (1922).[9] The most striking difference between the two analyses is in the nickel content; the higher percentage given in the present report may reflect improved methods of determining nickel. The 8.73% nickel reported here is higher than the nickel percentage usually given for coarse octahedrites; the nickel content has, however, been checked in quadruplicate.

Another small sample of the siderite, which contained a conspicuous crystal of schreibersite, was analyzed for the chemical composition of the schreibersite. Schreibersite is practically insoluble in dilute acids; hence, the specimen was allowed to stand in contact with dilute hydrochloric acid for 24 hours. The insoluble residue dissolved completely in *aqua regia*, and the resulting solution was analyzed for the schreibersite constituents. The results are shown in Table 1, column (3), and are consistent with the formula R_3P for schreibersite, where R = iron (Fe), nickel (Ni), and cobalt (Co).

TABLE 1

	(1) *Odessa*	(2) *Odessa*	(3) *Odessa Schreibersite*	*Ratios*	
Fe	90.30%	90.69%	67.46%	1.2079	
Ni	8.73	7.25	16.93	0.2885	= 3.03
Co	0.15	0.74	0.21	0.0036	
P	0.81	0.23	15.32	0.4945	= 1.00
S	0.02	0.03			
C	none	0.35			
Cu	none	0.02			
Pt	none	none			
Cr	trace	trace			
Mn	none	none			
Total	100.01%	99.31%	99.92%		
Molecular Ratio $\frac{Fe}{Ni}$ =	10.87	13.15			
Molecular Ratio $\frac{Fe}{Ni + Co}$ =	10.69	11.93			

(1): analysis by E. L. Martin.
(2): analysis by E. V. Shannon.
(3): analysis by Carl W. Beck.

Radiochemical Analysis of the Odessa Siderite.—The Odessa siderite is one of several siderites made available by the Institute of Meteoritics to Dr. Harrison Brown, Institute for Nuclear Studies, University of Chicago, for radiochemical analysis. Brown (1949) analyzed this specimen for gallium and palladium;[3] his results are given in Table 2, row (1). The corresponding results for the Albuquerque, New Mexico, and Canyon Diablo No. 1 and Canyon Diablo No. 2, Arizona, siderites

are given in the second, third, and fourth rows, respectively, of Table 2.

TABLE 2

	Gallium (Ga)	*Palladium (Pd)*
Odessa	69.3 p.p.m.	4.15 p.p.m.
Albuquerque	90.5	4.46
Canyon Diablo No. 1	77.4	3.98
Canyon Diablo No. 2	85.0	5.30

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The Glorieta Mountain, New Mexico, Siderite (ECN = + 1058,356)*

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ABSTRACT

The history of the recovery of the masses that comprize the Glorieta Mountain, New Mexico, siderite is reviewed. The present paper is based on a detailed mineralogical, metallographical, and chemical investigation of the remarkable cane-shaped specimen from the Department of Geology of the University of New Mexico. The meteoritic constituents present are kamacite, taenite, plessite, schreibersite, and lawrencite. The meteorite is classified as a medium octahedrite (Om).

INTRODUCTION

The first recoveries from the Glorieta Mountain, New Mexico, siderite fall were made by Mr. Charles Sponsler on August 9, 1884, on the ranch of Mrs. Roival, near Canoncito, Santa Fe County, New Mexico (ECN = + 1058,356). Mr. Sponsler, who had been prospecting on the Roival Ranch, imagined that he had stumbled upon a valuable ore deposit, despite the fact that the mass was found lying on top of a rock! The impact with the rock had shattered the meteorite into 3 fragments. Subseqently to Sponsler's initial discovery, Mr. J. H. Bullock, beginning in August, 1885, spent about 6 weeks in a careful examination of

*Read at the 13th Meeting of the Society, Flagstaff and Barringer Meteorite Crater, Arizona, 1950 September 5-7.

the area in which the masses of meteoritic iron had been found, and, as a result of his search and excavations, discovered 3 more masses of the fall. Since the discoveries made by Sponsler and Bullock in 1884 and 1885, the finding of an occasional, additional fragment of the Glorieta Mountain meteorite has been reported from time to time. At least 2 of these more recent finds (Albuquerque and Pojoaque) were initially assigned incorrectly to localities remote from Glorieta Mountain, but are now accredited to the shower that fell on and near the Roival Ranch.

In the order of decreasing size, the 6 masses found by Sponsler and Bullock may be described as follows: No. 1 weighs 148.5 pounds and clearly exhibits a surface of disruption; No. 2 weighs 115 pounds and shows not only a surface of rupture like that on No. 1 but also a flattened portion, 10×6 inches, which has been interpreted as the surface area that actually struck against the rock; No. 3 weighs 53.5 pounds and also shows a surface of rupture; No. 4 weighs 2.65 pounds and shows the effects of disruption over one-third of its surface, the area of fracture showing coarsely fibrous iron drawn out in the direction of the missing part; No. 5 weighs 2.48 pounds, and approximately five-sixths of the entire surface bears marks of violent disruption; No. 6 weighs 2.31 pounds and is very flat, the fracturing of the mass having left a nearly plane surface suggestive of a cleavage.

G. F. Kunz (1886),[1] after careful examination of Nos. 1 to 6, concluded that all of these pieces were fragments of a single large meteorite that "flew asunder" when it struck the rock on the Roival Ranch. He noted that the 148.5-pound piece was found only 8 feet from the 115-pound and 53.5-pound pieces, a fact that, in his opinion, demonstrated conclusively that the meteorite had burst on impact with the rock and not while traversing the air. Even the small fragments, Nos. 4, 5, and 6, were found at not more than 45 or 50 feet from the large masses, having been hurled to such distances because of their light weight. All of the fragments were buried at depths of from 3 to 10 inches in the vegetable mold that covers the solid rock in many places. Kunz attempted to reconstruct the original single mass from these 6 fragments, arriving at an individual with a length of 25 inches, a height of 10 inches, and a thickness of 15 inches (Kunz, *loc. cit.*,[1] p. 329).

In contrast to the opinion Kunz formed concerning the fragmentation of the meteorite, Brezina (1895; *loc. cit.*,[2] p. 280) regarded Glorieta Mountain as a siderite that, like Butsura, India (ECN $= \mp$ 841,271; cl. = C, i) had burst before reaching the Earth and had suffered partial fusion after the separation of the pieces in the air. In support of this view, Brezina called attention to the striking differences between the smooth surfaces, coated with fusion crust, which he interpreted as parts of the primary face, and the areas characterized by hackly fracture, occasionally slightly fused, which he regarded as the secondary surfaces.

A chemical analysis of fragment No. 3 of Glorieta Mountain, by

James B. MacKintosh of the School of Mines, New York City, gave the following results: Fe = 87.93%; Ni = 11.15%; Co = 0.33%; P = 0.36%; total = 99.77%. No other elements were determined.

A chemical analysis of the 7th mass recovered from the Glorieta Mountain fall was made by L. G. Eakins, with the following results: Fe = 88.760%; Ni = 9.860%; Co = 0.510%; Cu = 0.034%; Zn = 0.030%; Mn = trace; P = 0.182%; S = 0.012%; Si = 0.044%; total = 99.432%. Eakins regarded this analysis as corresponding to the following mineral composition:

Nickeliferous iron	98.224%
Troilite (FeS)	0.033
Schreibersite ($(Ni_2Fe)_3P$)	1.175
Total	99.432%

Altho Cohen, Weinschenk, and Brezina have studied certain features of the Glorieta Mountain meteorite, this siderite has not received the attention that its many meteoritic characteristics merit. The present paper is based on a mineralogical, metallographical, and chemical investigation of a remarkable specimen of the Glorieta Mountain fall (No. IOM-7 in the collection of the Institute of Meteoritics), weighing 3 pounds and 12 ounces.

Macroscopic Examination

A macroscopic examination of this specimen of the Glorieta Mountain fall reveals that the specimen is a club-shaped, or cane-shaped, siderite, 23 cm. long, with a cross-section about 4 cm. in each direction at the widest part (Fig. 1A). The specimen has been sliced, polished,

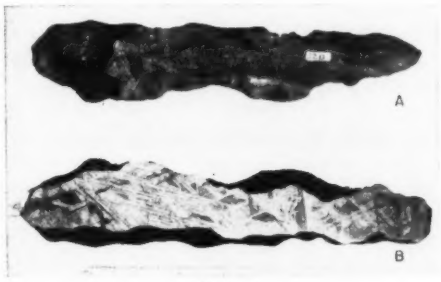

Fig. 1
The Glorieta Mountain, New Mexico, Siderite: A. Exterior Surface; B. Macroetched Surface; Scale in Inches

and macroetched along one side (Fig. 1B). Small sections have been removed from one end, one a cross-section and one a section parallel to the long axis, in order to make polished sections for metallographic study.

The weathered surface is characterized by angular pittings. The

angularity of these pits is a rather unusual feature of meteoritic irons. The long club-shaped, or cane-shaped, habit of this specimen of the Glorieta Mountain fall also is unusual. The color of the weathered surface is the reddish-brown so common to siderites.

The macroetched surface shows the iron to be a medium octahedrite (Om). The kamacite plates, which range in thickness from 0.4 to 1.0 mm., traverse the surface in as many as 4 directions. The kamacite plates are bounded by thinner taenite lamellae, and the angular interstices are filled by plessite fields. A few small areas have been deeply etched and appear granular. It is thought that this granular appearance indicates areas that had a loosely granular structure before etching and were more deeply etched because of the greater surface area exposed to the dissolving action of the etchant.

This fall consists of a number of irons, some of which are said to possess pallasitic areas, or areas containing large grains of olivine enmeshed in a network of nickel-iron. The specimen studied for this report exhibits no such pallasitic areas, however.

Microscopic Examination

Two (2) slices of the Glorieta Mountain siderite, one cut parallel to the long axis of the specimen and the other at right angles to it, were mounted in bakelite, polished, etched with nital for 15 sec., and studied with the metallographic microscope. Examination of the polished sections before etching revealed small amounts of lawrencite (Fig. 2A) with a random distribution. The lawrencite appears to be concentrated along boundaries of kamacite grains or along fractures in kamacite plates. The chemical analysis (Table 1) shows the presence of appreciable chloride.

The microscopic examination confirms the structure as being that of a medium octahedrite (Om). The majority of the kamacite lamellae fall in the range of 0.25 to 1.0 mm., tho some extremely fine lamellae (0.05 mm.) and some thick lamellae (up to 1.75 mm.) are evident in the sections.

The external zone of alteration is not very great, reaching a maximum depth of 0.5 mm. The interior of the siderite, with the exception of the aforementioned lawrencite, is free from alteration. From the unaltered appearance of the meteoritic constituents, as well as from the lack of extensive external oxidation, it may be inferred that the meteorite did not undergo severe heating during its flight thru the atmosphere.

The meteoritic constituents present are kamacite, taenite, plessite, lawrencite, and a small percentage of schreibersite. The principal component is kamacite, in bands crossing one another in as many as 4 directions, to give the octahedral structure. For the most part, the kamacite is structureless, tho occasionally Neumann lines are seen.

Taenite occurs either as thin lamellae bordering the kamacite or as highly irregular, angular grains in light plessite, or as a component of dark plessite (Fig. 2C). The bordering taenite is thickest where 2

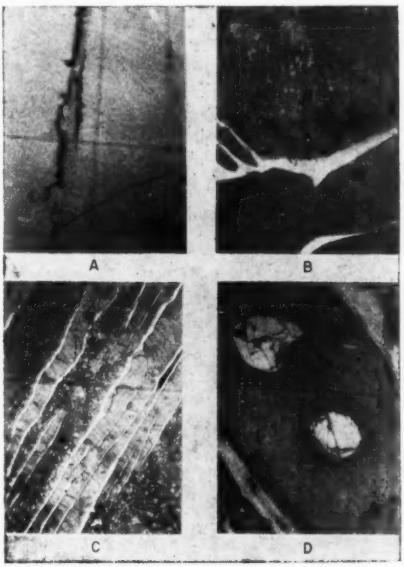

FIG. 2

The Glorieta Mountain, New Mexico, Siderite: A. Lawrencite in kamacite; B. "Comb" structure: kamacite, taenite, and dark plessite; C. Light, elongate plessite interspersed among kamacite and taenite lamellae; D. Schreibersite in equant, euhedral crystals; × 40:.

lamellae cross each other, and thins away from the intersection. Taenite occurs also in the light plessite in the arrangement referred to by German writers as *Kämme* (combs) (Fig. 2B); furthermore, the taenite bands are thickest at the border of the light-plessite field, and thin towards the center of the field.

Plessite, both the light and the dark variety, is abundantly present in the polished sections, generally filling the angular interstices of the octahedral structure (Figs. 2B & 2C). The light, or normal, variety is the predominant type of plessite. It is found typically in the octahedral structure, but it is found also in elongate fields interspersed among kamacite and taenite lamellae (Fig. 2C). Some dense plessite also was found occupying a similar position. The dense plessite occurs also in rectangular fields bounded by taenite, and as a component of the comb arrangement (Fig. 2B).

Schreibersite is not an abundant constituent, but it occurs as equant, fairly euhedral, tetragonal crystals (Fig. 2D). The greatest number of these schreibersite crystals fall in the range of 0.1 to 0.2 mm. It is to be noted in the chemical analysis (Table 1) that an extremely small percentage of phosphorus is indicated, much smaller than the microscopic examination would indicate; evidently the sample taken for

chemical analysis failed to include many of the numerous isolated grains of schreibersite.

No troilite was noted in the polished sections, and the chemical analysis (Table 1) confirms the absence of sulfur.

Chemical Analysis

A chemical analysis of a representative sample of the Glorieta Mountain siderite was made by Dr. E. L. Martin, Department of Chemistry, University of New Mexico. The results are shown in Table 1.

Table 1

Chemical Analysis of the Glorieta Mountain Siderite

Fe	88.37%
Ni	10.39
Co	0.84
Cl	0.48
Cu	0.00
S	0.00
P	0.001
Total	100.081%

$$\text{Molecular Ratio } \frac{\text{Fe}}{\text{Ni}} = 8.96$$

$$\text{Molecular Ratio } \frac{\text{Fe}}{\text{Ni} + \text{Co}} = 8.29$$

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Notice of the 14th Meeting of the Society

The Council of the Meteoritical Society announces that the 14th Meeting of the Society will be held in conjunction with the next annual meeting of the Pacific Division of the American Association for the Advancement of Science, on Monday, Tuesday, and Wednesday, June 18-20, 1951, at the University of Southern California, Los Angeles 7, California. The Society shares invitations with the Astronomical Society of the Pacific, which will meet at the same time and place, to visit the Griffith Observatory on Monday evening, June 18, and the Mount Wilson Observatory on Wednesday afternoon, June 20.

Members of the Society are hereby requested to send the undersigned, at their earliest convenience, the titles and abstracts (the latter in form for publication in *C.M.S.*) of any papers that they may wish to present, or to have presented, at the forthcoming meeting.

John A. Russell, *Secretary*

Errata in the January, 1951, Issue.—In "The Spectrum of a Perseid Meteor of 1949," by John A. Russell, *C.M.S., P.A.*, **59**, 28-33, Jan.,

1951, (1) the last datum ("observed wavelength" in A.) in the first column of Table 1, p. 29, should read "6131.5," instead of "6135.5," and (2) "density-variation," in the legend of Fig. 2, p. 31, should read "density-variations."

President of the Society: L. F. Brady, 922½ Forest Avenue, Tempe, Arizona
Secretary of the Society: John A. Russell, Department of Astronomy, University of Southern California, Los Angeles 7, California

The Planets in April, 1951

By RAYMOND H. WILSON, JR.

Note: The time employed is Central Standard Time unless otherwise indicated. The phenomena have been chosen and described for the North American continent, and especially for the United States. The basic data have been taken principally from the *American Ephemeris and Nautical Almanac.*

Sun. The sun will be climbing rapidly northward so that, at the end of the month, it will be nearly 15 degrees north of the equator, and daylight will last as long as in August.

Moon. The phases of the moon will occur as follows:

New Moon	April 6	5 A.M.
First Quarter	14	7 A.M.
Full Moon	21	4 P.M.
Last Quarter	28	6 A.M.

The moon will be at perigee on April 23.

Evening and Morning Stars. One will be able to see Venus and Saturn in the evening sky, and Jupiter just before sunrise.

Mercury. Mercury will stand at a maximum of 19 degrees northeast of the sun on April 5. Hence the first half of this month will offer the most favorable evening views of this elusive planet. On the evening of April 7 the crescent moon will be only a degree north of it.

Venus. The most conspicuous object in the early evening sky, Venus, will be setting nearly 3 hours later than the sun by the end of this month.

Mars. Although still a few degrees east of the sun, Mars will be practically invisible this month.

Jupiter. Jupiter will be increasingly conspicuous in the eastern dawn, and, by the end of the month, will be rising 2 hours ahead of the sun.

Saturn. This month Saturn will be south at about 10 P.M. It will be situated about midway between Regulus and Spica.

Uranus. Uranus will be moving slowly southeastward, almost halfway between μ and ϵ Geminorum.

Neptune. Neptune will be in opposition to the sun on April 8, at a position half a degree south of θ Virginis.

Department of Mathematics, Temple University, Philadelphia, Pa.
February 10, 1951.

Occultation Predictions for April, 1951

(Taken from the *American Ephemeris*)

The quantities in the columns *a* and *b* are given for the purpose of making these predictions useful for any place within 200 miles of the point indicated. The procedure is as follows: Subtract the longitude of the point given from the longitude of the place in question; multiply the result in degrees, taking the signs into account, by the quantity under *a* for the star to be observed; similarly, with the latitude, using *b*; apply the sum of the products, with its proper sign, to the Greenwich C.T., and obtain the predicted Greenwich Civil Time for the phenomenon at the place of observation. To obtain Eastern Standard Time it is necessary to subtract five hours; Central Standard Time, six hours, etc.

			IMMERSION				EMERSION			
Date 1951	Star	Mag.	Greenwich C.T.	*a*	*b*	Angle E from N	Greenwich C.T.	*a*	*b*	Angle E from N
			h m	m	m	°	h m	m	m	°
	OCCULTATIONS VISIBLE IN LONGITUDE +72° 30′, LATITUDE +42° 30′									
Apr. 9	*q* Taur	4.4	23 19.1	−0.8	−2.0	105	0 23.7	−0.7	−0.4	238
9	21 Taur	5.8	23 41.3	−0.7	−1.4	90	0 48.7	−0.4	−0.9	254
9	22 Taur	6.5	23 46.3	−0.6	−1.7	98	0 51.5	−0.4	−0.7	247
9	20 Taur	4.0	23 53.1	+0.2	−4.7	142	0 26.3	−1.5	+2.0	201
10	BD+26°731	6.5	23 46.0	−0.9	−1.9	106	0 55.4	−0.7	−0.8	252
18	83 Leon	6.2	22 40.6	−0.7	−0.3	135	23 48.7	−1.2	+0.2	295
18	τ Leon	5.2	23 21.7	−0.9	−0.2	128	0 33.8	−1.3	−0.4	306
	OCCULTATIONS VISIBLE IN LONGITUDE +91° 0′, LATITUDE +40° 0′									
Apr. 9	*q* Taur	4.4	23 4.6	−1.6	−3.6	127	23 58.8	−1.8	+2.0	209
9	18 Taur	5.6	23 13.5	−1.9	+2.0	34	0 10.8	−0.8	−3.1	304
9	21 Taur	5.8	23 26.6	−1.5	−2.3	112	0 33.7	−1.4	+0.5	228
9	22 Taur	6.5	23 35.1	−1.3	−3.1	121	0 34.0	−1.5	+1.0	218
10	BD+26°731	6.5	23 30.7	−1.5	−3.6	132	0 29.6	−2.1	+1.5	220
18	τ Leon	5.2	23 11.0	−0.4	−0.9	150	0 9.4	−1.2	+1.1	275
	OCCULTATIONS VISIBLE IN LONGITUDE +98° 0′, LATITUDE +31° 0′									
	No occultations listed in *American Ephemeris* for this point for April.									
	OCCULTATIONS VISIBLE IN LONGITUDE +120° 0′, LATITUDE +36° 0′									
Apr. 9	ε Arie	4.6	1 30.0	−1.1	−2.5	113	2 27.9	−1.2	+1.0	216
13	49 Auri	5.0	4 0.9	−2.5	+0.6	58	4 51.8	+0.3	−3.6	336

Meteor Notes from the American Meteor Society

By CHARLES P. OLIVIER, President

This year had a good start for the A.M.S. in that five members braved the cold during the possible duration of the Quadrantid meteors and have already sent in what they accomplished. Of course, some others may have observed and not yet reported.

The best way to give their results will be in tabular form, as follows:

Station, Time, Observer	Date	Began	Ended	Min.	Met.	F	Hourly Rate Unc.	Obs.	C
Cape Elizabeth, Maine—E.S.T.									
Dole, R. M.	Dec. 31.68	11:00	11:30	30	11	1.0	22	1	P
	Jan. 1.67	9:00	13:05	?	8	0.2	..	1	P
	2.46	5:00	7:00	120	1	0.8		1	P
	2.62	9:00	11:00	120	4	0.1		1	P
	4.71	11:30	12:30	60	11	1.0	11	1	P

Station, Time, Observer	Date	Began	Ended	Min.	Met.	F	Hourly Rate Unc.	Obs.	C
Marblehead, Mass.—E.S.T.									
Knowles, J. H.	Dec. 31.85	13:30	17:49	250	19	0.7	5	1	P
	Jan. 1.81	12:20	16:30	250	29	0.8	7	1	P
Forest Hills, N. Y.—E.S.T.									
Pearlmutter, A.	Jan. 1.59	8:44	9:44	60	16	0.7	16	1	P
	1.68	10:54	11:36	42	11	0.7	16	1	P
	1.87	15:03	16:35	92	19	0.5	12	1	P
	4.66	10:12	11:41	75	22	0.5	18	1	P
	4.95	17:22	18:22	60	12	0.3	12	1	P
Enid, Okla.—C.S.T.									
Fisher, H. L.	Jan. 3.66	8:30	11:15	165	12	1.0	4	1	P
Bonita, Ari.—M.S.T.									
Roat, Miss E. C.	Jan. 3.83	12:00	14:00	120	8	1.0	4	1	D

Note: The Dec. 31 dates are in 1950, the Jan. dates in 1951.

As for radiants, on Dole's maps for Dec. 31, of the 11 meteors thereon, one only could be a Quadrantid if we take the radiant near $\alpha = 231°$, $\delta = +51°$. The rest seem to radiate from a large region centered at α Urs. Maj. On Jan. 1, 6 out of 8 fit one radiant, namely A.M.S. No. 3139, $\alpha = 168°$, $\delta = +60½°$, good. On Jan. 4, A.M.S. No. 3140, $\alpha = 214°$, $\delta = +52½°$, good, fits 6 meteors out of 10. Of the 4 non-conforming, 2 probably are from a sub-radiant very near A.M.S. No. 3139; the other 2 are definitely sporadic. If Denning's radiant, $\alpha = 231°$, $\delta = 51°$, is indeed still correct, none but 2 of Dole's 35 plotted meteors could have come from anywhere near it.

A full study of Pearlmutter's maps has been made, with the following conclusions. On Jan. 1, there is a very diffuse radiant of Quadrantids, centered at $\alpha = 227°$, $\delta = +47°$. This is A.M.S. No. 3141, and is based upon 8 meteors on Map I. On Map VI we find a very sharp and well-defined radiant, A.M.S. No. 3142, at $\alpha = 220°$, $\delta = +38°$, based upon 6 meteors. At least 2 of the 8 defining A.M.S. No. 3141 would also intersect this center. On Jan. 4, we have confirmation of A.M.S. No. 3142 by 6 meteors which give a diffuse radiant A.M.S. No. 3143 at $\alpha = 214°$, $\delta = +39°$. However, 11 meteors give a good radiant at $\alpha = 235°$, $\delta = +29°$. This is A.M.S. No. 3144. We also have an uncertain radiant, therefore unnumbered, at $\alpha = 180°$, $\delta = +46°$, based on 3 meteors.

Only a résumé of Knowles' observations has come but in it he reports two radiants on Jan. 1, as follows: A.M.S. No. 3145, $\alpha = 179°$, $\delta = +35°$, 4 meteors, f.g.; and No. 3146, $\alpha = 196°$, $\delta = +60°$, 5 meteors, good. He says he saw no Quadrantids.

A general survey of all the maps mentioned, assuming of course that the plotting is at least fairly accurate, give the impression that, on these nights, the true Quadrantids were mostly absent. This may of course be explained by the assumption that the observers missed the maximum, which indeed may last only a few hours. Only when one is lucky enough to strike the maximum is the hourly rate of these meteors likely to be high. But, in any case, I believe that most recent observers have found a diffuse radiating area, rather than a sharp center even when many Quadrantids appear.

It is too bad that our members in the far South, where weather is certainly milder, do not make an effort to observe during this epoch. The stream is certainly an important one and we know too little about it. Only good observations, made in many places and over many years, can fill this gap in our knowledge. Cannot all members everywhere really try for the Lyrids in April and more

especially for the Eta Aquarids during the first week of May? We want more reports on the latter very badly.

Perhaps the greatest need of our Society at present is that in most states we have no one who is willing and trained to act promptly when a fine fireball appears. Due to this, isolated reports come in of objects of the greatest interest, but not enough observations in most cases to determine either heights or orbits. The loss is most keenly felt when the fireball has left a long-enduring train.

As the public is now greatly interested in science generally, and a considerable percent is what might be called meteor-conscious (in this, interest in flying saucers has doubtless largely contributed), newspapers and even radio stations are most willing to publish or broadcast requests for observations. But, unless in the region over which the fireball appears, we have an able member acting as regional director, who will set the wheels in motion, the opportunity is generally lost. It is really impracticable if not impossible to conduct such a campaign from our headquarters here if the region is more than a couple of hundred miles distant.

The appeal is therefore again made to our members for some to volunteer to act under such circumstances. But do *not* volunteer unless you intend to really act! Acting includes calling up your local paper, and getting in touch with one of the national newspaper networks through them. Ask all eyewitnesses to write you telling what they saw, specifying particularly that they give (1) the direction and angular height of the point where the object was first seen, (2) the same for where it was last seen, (3) how bright it was compared to Moon or planets, (4) a description of any train left. When such letters come, if the observer answers intelligently, send him a copy of *Bulletin No. 16*, asking him to fill this out as completely as possible and return promptly. If there is a local or nearby radio station, call it asking it to request that persons who saw the object write you. In this case, the radio announcer will not give all the details you get into a paper but he will give out the request with your name and address. When you hear from people, as before, send them No. 16, with a note asking that they please fill it out and return.

It is usually a full month before all letters and questionnaires are in. When they are, the whole should be forwarded to Flower Observatory, unless the regional director desires to try a solution himself. In this case, I will be most pleased to aid him in the various problems which always arise.

To date, Prof. J. Hugh Pruett, University of Oregon, Eugene, Oregon, is the person who has been most successful in gathering reports in great numbers on very many fireballs, and, in numerous cases, has made a partial or full solution for their atmospheric paths. What he has done, others could do if they used an equal amount of effort and judgment. Cannot at least a few such persons be found? *Bulletin No. 16* is of course furnished by us, free on request, to our regional directors, in all needed quantities.

Again to any professional astronomer, or to other qualified person, we are happy to send data in our files referring to any object we have not ourselves solved and they may wish to, where they already have more data than we, or are in a much better position to secure personal information.

As an example of such cooperation, the observations in my hands on the 1950 November 2 fireball over New England and Canada have been loaned to Dr. P. M. Millman of the Dominion Observatory, Canada. He already had about 200. I had between 10 and 20. Hence it is far better that ours be added to his thus enabling him to make the very best solution rather than for me to attempt one

with less than one tenth the data. Also no one is better qualified to carry out such a solution than he. Were the circumstances reversed, he would gladly reciprocate.

A solution of the great Gulf States fireball of 1950 June 23 is, on the contrary, being still carried on by O. E. Monnig of Texas and myself. My part is working out the atmospheric path and orbit; his is interviewing personally, if possible, people who photographed or otherwise observed the long-enduring train. Each will check on the numerical work of the other and the paper will appear over our joint signature, in the near future, we hope. This was a truly splendid object and deserves special study.

Data in our files on many other fireballs await opportunities for solution. I hope to see a number finished this year.

With regard to our Society, in general, a certain number of members have already sent in their dues for 1951. Will the rest please do so? Copies of *Flower Observatory Reprint No. 79*, containing results on telescopic meteors up to 1949 inclusive, have been mailed to all persons who contributed an appreciable number of observations and whose address could be found. It, as well as No. 84 containing Meteor Notes for 1950, has also been mailed to all whose 1951 dues have come and who did anything in 1950. Others will receive No. 84 when their dues are paid.

Some preliminary work on the annual report has been done, but there is reason to believe some of our members have not sent in all their observations. May I urge them to do this so that they may have full credit in the annual report. I generally try to have this ready by March 15, at latest. Incidentally, I am pretty sure that 1950 will considerably surpass 1949 in total work done. We had members who sent in a very large number of observations during the year, including several new members who started off with great enthusiasm.

Flower Observatory, University of Pennsylvania, 1951 Jan. 26.

VARIABLE STARS

Variable Star Notes from the American Association of Variable Star Observers

By MARGARET W. MAYALL, Recorder

SS Cygni in 1950. SS Cygni continues to be a favorite star for observers all over the world. More than 1450 observations of it were made on 305 nights during the year. There were 6 observed maxima in 1950, 4 of the A-type, 1 B-, and 1 C-type. The alternation of wide and narrow maxima was very striking. One 10-day gap occurred in the observations from February 23 to March 6, but it does not seem likely that there could have been a maximum during that period.

The intervals between maxima were somewhat longer than normal. The mean cycle for the year was 65.3 days, as compared with 52.0 days for the 381 maxima since the discovery of SS Cygni in 1896.

Table I is a continuation of the table of daily means for 1949, given in these Variable Star Notes for February, 1950, (*P. A.*, **58**, 90). Table II lists the observed maxima of the year, in the same form as that used in the past. The mean light curve for 420 days, from J.D. 2433240 to 3660, is shown in the figure.

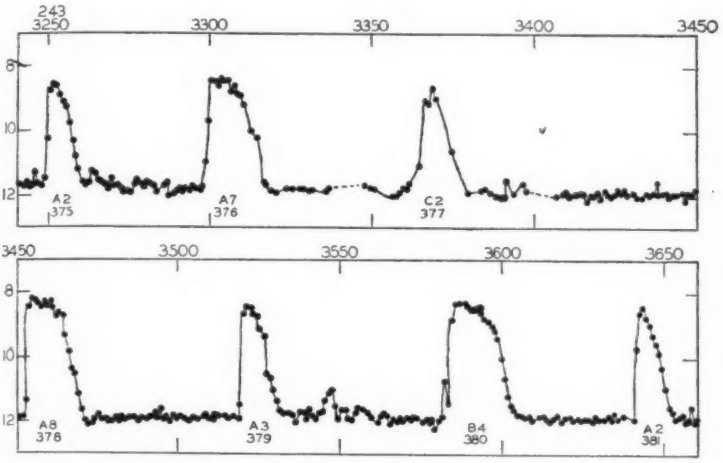
Our thanks are due to Axel V. Nielsen, for sending us 217 observations made by 11 members of the Scandinavian Astronomisk Selskab. These observations, as usual, fill in many gaps in our light curve.

TABLE I

DAILY MEANS

213843 SS CYGNI J.D. 2433250-3649

J.D.	—0— m_v	No.	—1— m_v	No.	—2— m_v	No.	—3— m_v	No.	—4— m_v	No.	—5— m_v	No.	—6— m_v	No.	—7— m_v	No.	—8— m_v	No.	—9— m_v	No.
3250	8.75	4	8.59	7	8.60	4	8.90	6	9.10	6	9.24	5	9.74	5	10.32	8	10.80	5	11.20	2
60	11.60	4	11.64	5	11.60	3	11.23	6	11.38	10	11.57	7	11.59	12	11.65	4	11.80	3	11.50	4
70	11.72	4	11.72	6	11.80	2	11.88	4	11.88	6	11.90	3	11.68	4	11.53	6	11.66	5	11.74	7
80	11.60	4	11.65	6	11.70	3	11.9	1	.....		11.75	2	11.70	2	12.0	1	11.95	2	11.85	4
90	11.79	10	11.87	3	11.80	5	11.85	6	11.73	3	11.80	2	11.80	3	11.75	2	10.96	7	9.73	3
3300	8.42	8	8.47	10	8.60	2	8.40	2	8.45	6	8.50	2	8.8	1	8.68	6	8.85	2	8.90	3
10	9.2	1	.....		10.0	1	.....		10.2	1	.....		11.60	3	11.67	3	11.85	2	.....	
20	11.9	1	.....		.....		11.80	3	.....		11.8	1	.....		11.8	1	11.8	1	11.85	2
30	11.87	3	11.82	5	.....		.....		.....		11.87	3	11.8	1	.....		.....		.....	
40	.....		.....		.....		.....		.....		.....		.....		11.7	1	.....		11.8	1
50	11.8	1	.....		.....		.....		.....		.....		12.0	1	12.0	1	11.95	2	11.8	1
60	11.80	2	11.6	1	.....		.....		10.1	1	.....		9.05	2	9.15	2	8.7	1	9.00	2
70	.....		.....		.....		.....		10.6	1	.....		.....		.....		.....		11.90	2
80	.....		.....		.....		11.85	2	11.8	1	.....		11.9	1	.....		12.0	1	12.0	1
90	12.0	1	11.50	2	.....		11.93	3	.....		.....		11.6	1	11.85	2	.....		.....	
3400	.....		.....		<10.0	1	.....		.....		.....		12.0	1	.....		11.95	2	11.85	2
10	12.00	2	11.98	4	11.95	2	11.95	2	11.92	6	11.92	5	12.13	3	12.00	3	11.95	2	11.87	3
20	12.05	2	11.80	3	11.92	5	12.00	2	11.95	2	11.8	1	11.90	4	11.80	3	11.95	4	.....	
30	11.9	1	12.0	1	.....		12.0	1	11.90	2	11.94	5	11.93	3	11.59	7	11.92	10	11.90	5
40	11.87	6	12.00	2	11.95	2	11.96	5	11.88	8	11.86	5	12.15	2	11.90	2	11.9	1	11.80	2
50	11.84	5	11.83	3	11.36	5	8.46	5	8.2	1	8.26	5	8.28	5	8.42	5	8.33	9	8.42	5
60	8.33	9	8.51	9	8.75	8	8.70	12	8.78	10	9.35	14	9.81	9	10.38	11	10.50	3	11.16	8
70	11.61	14	11.95	6	12.06	5	12.05	2	11.90	2	11.82	5	11.94	5	11.90	8	11.98	8	11.98	4
80	11.90	6	12.00	4	11.85	4	11.89	6	11.88	9	11.90	4	11.85	2	11.95	2	11.90	2	11.88	4
90	11.92	4	11.87	3	11.77	3	11.88	5	11.6	1	11.92	4	11.85	2	11.98	5	11.82	11	11.87	9
3500	11.83	11	11.88	10	11.92	10	11.95	6	11.86	5	11.92	5	11.95	6	11.84	12	11.77	7	11.88	5
10	11.90	4	11.76	5	11.80	10	11.82	8	11.80	9	11.86	10	11.91	13	11.82	4	11.88	4	11.43	9
20	8.64	5	8.42	10	8.46	9	8.66	5	8.75	12	9.12	7	9.38	9	10.52	4	10.63	6	11.00	12
30	11.35	11	11.62	5	11.69	9	11.79	7	11.72	8	11.80	3	12.00	2	11.68	8	11.68	5	11.9	1
40	11.60	3	11.80	10	11.85	8	11.74	8	11.72	5	11.35	2	11.1	1	11.00	4	11.46	5	11.90	4
50	11.60	4	11.6	1	11.90	2	11.90	5	11.70	6	11.52	4	11.59	8	11.60	10	11.78	5	11.82	11
60	11.82	11	11.98	5	11.82	5	11.73	3	11.80	4	12.04	5	11.88	6	11.94	5	11.88	6	11.94	5
70	11.88	10	11.88	11	11.80	5	11.80	4	11.90	4	12.00	7	11.88	5	12.0	1	11.9	1	12.2	1
80	11.93	3	11.82	4	10.73	3	11.40	2	8.82	7	8.34	13	8.35	15	8.32	16	8.30	8	8.38	4
90	8.50	5	8.50	13	8.45	15	8.60	9	8.81	8	8.88	13	9.02	10	9.18	11	9.41	9	10.00	12
3600	10.61	10	11.19	8	11.44	8	11.65	4	11.73	7	11.78	4	11.82	4	11.80	2	11.90	2	.....	
10	.....		11.80	3	11.80	3	11.90	4	11.95	2	11.90	2	11.80	3	11.85	4	11.97	3	11.88	4
20	11.8	1	11.92	4	11.89	7	11.87	3	11.90	4	11.90	8	11.90	3	11.93	3	11.8	1	11.85	4
30	11.87	6	11.88	6	11.80	2	11.90	5	11.70	3	11.87	3	.....		11.8	1	.....		<11.5	1
3630	11.9	3	9.73	3	8.60	3	8.44	9	8.75	8	9.00	4	9.28	4	9.56	8	9.84	6	10.3	1



SS CYGNI, 213843, DAILY MEANS IN 1950

TABLE II

No. Max.	Type	J.D. 10.0 I	Diff.	J.D. Max.	Diff.	J.D. 10.0 D	Diff.	Max. Mag.
376	A7	2433299	50	2433303	51	2433312	55	8.4
377	C2	3365	66	3368	65	3373	61	8.7
378	A8	3452	87	3457	89	3467	94	8.3
379	A3	3520	68	3522	65	3527	60	8.5
380	B4	3583	63	3590	68	3600	73	8.3
381	A2	3641	58	3643	53	3649	49	8.4

Observations received during January. A total of 3,223 estimates was received during the month from 46 observers, as follows.

Observer	No. Var.	No. Ests.	Observer	No. Var.	No. Ests.
Adams	55	112	Halbach	115	149
Ahnert	9	16	Hartmann	162	170
Ball	8	8	Jerabek	3	3
Bicknell	10	21	Kelly	10	10
Bogard	46	59	Kelsey	2	5
Buckstaff	7	9	Knowles	8	14
Burkhead	5	5	de Kock	116	442
Cain	2	2	Lacchini	39	49
Cobb	2	2	LeVaux	90	92
Cragg	100	100	Luft	7	44
Darsenius	3	25	Melville	12	19
Diedrich, DeL.	1	2	Miller	6	6
Diedrich, G.	1	2	Milone	21	32
Estremadoyro, V. A.	6	8	Morrisby	9	12
Fernald	175	271	Motley	15	22
Ford	5	5	Oravec	66	230
Galbraith	34	167	O'Sullivan	16	33
Greenley	86	176	Peltier	31	145

Observer	No. Var.	No. Ests.	Observer	No. Var.	No. Ests.
Penhallow	2	2	Tifft	2	5
Pohl	27	278	Upton	20	20
Renner	108	108	Venter	31	44
Rosebrugh	16	36	Yamada	16	27
Schulte	10	13	—		—
Taboada	159	223	46	totals	3,223

Nova Search. Nova Search reports were received during January from 12 observers. These include reports from 5 members of the Nova Search Section of the Montreal Center of the R.A.S.C.

Observer	Area	No. Nights	Mag.	Observer	Area	No. Nights	Mag.
Adams	16, 17, 31, 32	3	8	Milton	46	2	6
	16, 17, 31, 32	2	7	Morgan	34	1	6
Bridgen	33	1	6	Noseworthy	82	6	6
DeKinder	36	2	6	Rick	Dome	6	1
Diedrich, DeL.	94	1	5		18	5	4
	94	1	4		18, 63	1	3
Diedrich, G.	Dome	2	1		63, 65	4	4
	56	1	6		65	2	3
	56	1	5	Rosebrugh	Dome	2	3
	56	2	4	Smith	3, 4	4	6
Luft	25, 26, 27	7	5				
	33, 34, 35	4	5				

February 15, 1951.

Comet Notes

By G. VAN BIESBROECK

There has been a sudden burst of cometary activity early this month. COMET 1951 *a* (PAJDUSAKOVA), the first new one of this year, was discovered at the mountain observatory of Skalnaté—Pleso in Czechoslovakia on the morning of February 4. Several comets have been found there in recent years as a result of a systematic search. Miss Ludmila Pajdusakova, who previously discovered COMET 1948 *d*, found the present object at low altitude before sunrise in the constellation of the Dolphin and gave the following rough position:

1951 Feb. 4.2111 $20^h\ 34^m + 15^\circ\ 0'$.

She described it as being of 9th magnitude with a tail less than a degree in length.

In the clear sky of this observatory the newcomer was easily picked up the next morning and found to be moving northeastward. Fig. 1 represents its appearance on a one-minute exposure with the 82-inch reflector on the morning of February 10. There is no sharp nucleus; the head, about 20″ in diameter, melts out in a short tail which falls off rapidly over a length of 4 to 5 minutes of arc. The magnitude, estimated visually by extrafocal comparisons with known stars, seems to have oscillated somewhat but it was 8.5 when the exposure was made. The next day, February 11, the estimate was 8.2.

Joseph Brady of the University of California, Berkeley, has computed the following parabolic elements for this comet which were transmitted by wire on February 13:

Perihelion	1951 Jan. 30.114 U.T.
Node to perihelion	67° 29′
Longitude to node	310 07
Inclination	87 46
Perihelion distance	0.7254 astr. units.

He also gives the following ephemeris:

1951	α h m	δ ° ′	L.I.*
Feb. 13	20 59.1	+25 35	1.1
23	21 47.2	39 35	
Mar. 5	23 17.7	53 19	
15	1 45.8	+59 46	0.7

which shows that the comet will not change much in brightness for some time and will be very well placed for northern observers.

FIG. 1
COMET 1951 *a* (PAJDUSAKOVA)
FEBRUARY 10, 1951

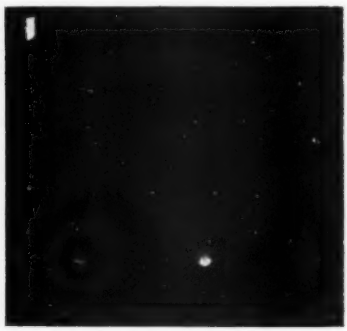


FIG. 2
COMET 1951 *b* (AREND-RIGAUX)
FEBRUARY 10, 1951

COMET 1951 *b* (AREND-RIGAUX) was telegraphically announced on February 9 but already discovered on February 5 by these two Belgian astronomers who evidently must have found it in the course of their photographic work on asteroids. The first information was:

1951 Feb. 5.08486 $7^h 22^m.8$ $+23° 39'$
Daily motion $+56'$ and $+29'$
Magnitude 11 Diffuse with central condensation.

Fig. 2 shows the aspect on February 10 from a 10-minute exposure with the 82-inch reflector. The plate was moved with the motion of the comet so that the stars appear as little trails. The comet shows a stellar nucleus and only a faint coma which spreads out in a short fan of some 40″ in position angle 30°. Not until orbit computations have been made will it be possible to know whether this faint object is brightening up.

The expected PERIODIC COMET 1951 *c* (PONS-WINNECKE) was recognized by the writer as a minute starlike object moving along the predicted path on plates taken here February 7, 8, and 9 at the prime focus of the 82-inch reflector. By comparing the comet with the polar sequence the magnitude was estimated be-

*Light Intensity as compared with that at discovery as unity.

tween 20.1 and 19.8. The following position in the constellation of the Hunting Dogs,

1951 Feb. 9.24814 $11^h\ 24^m\ 56^s.65$ $+35°\ 0'\ 25''.8$ (1950.0),

shows that the ephemeris by Calway and Porter (*Handb. B. A. A.* 1951, p. 41) requires only a small correction of $+0^m.4$ and $-2'$. This corresponds to a change less than 6 hours in the time of perihelion passage which is still as far off as August 22. The comet will be well situated during the coming months, gradually gaining in brightness until it reaches a maximum of 12.7 in September, after which visibility will be limited to the southern hemisphere. This comet has already a long history beginning with the original discovery in 1819 by Pons at Marseille (France). It was independently rediscovered by Winnecke in 1858 and has been well followed since that time. The present prediction was based on elements deduced from the 1939 and 1945 observations, planetary perturbations being taken into account.

Aside from these three recent additions to the list of comets a long list of previously discovered ones has been under observation. They are in order of increasing right ascension:

Periodic Comet 1950 *e* (Encke)—It gains in brightness and the fanshaped tail mentioned last month becomes more prominent as foreseen. Since it will reach 8th magnitude in March it will come in reach of small instruments for a few days before it is lost in the western sky. Its positions for three dates are

1951	h m α	° ′ δ
Feb. 23	0 14.3	+ 9 04
Mar. 5	27.8	8 31
15	0 12.3	+ 1 30.

Periodic Comet 1950 *c* (Wolf)—Plates taken here early this month no longer show a trace of this faint object which must now be well below 20th magnitude.

Periodic Comet 1950 *a* (D'Arrest) was still recorded here as a faint fuzzy spot on February 5 and 6 when the magnitude had dropped to 19. It is doubtful if further observation will be obtained during this apparition which, beginning last April, covers a period of nearly 10 months.

Comet 1949 *a* (Johnson) appeared as a well-defined round coma, some 6″ in diameter, of magnitude 17 when last recorded here February 8. It remains at high declination and may therefore be followed longer. The duration of visibility extends already to 21 months.

Periodic Comet 1925 II (Schwassmann-Wachmann). During the recent dark of the moon this comet has not shown any of its previously recorded large fluctuations in brightness but remained as a well-condensed dissymetrical small coma of magnitude 16 to 17.

Periodic Comet 1950 *d* (Daniel) appeared early this month as a diffuse coma of magnitude 18. Since it is gradually fading the period of observation which began last August may not be extended much further.

Periodic Comet 1943 *a* (Oterma) follows closely its predicted course and does change little in appearance. In January and February the magnitude was about 15 and the well-condensed little coma was preceded by a narrow tail some 3′ long in the fourth quadrant.

Comet 1950 *b* (Minkowski) has now well passed perihelion and the extension of the tail is diminishing. Next month it reaches minimum distance from the

earth and the computed brightness is 8.9 in the middle of March. It may, however, not reach that brightness since on January 8, when the predicted magnitude was 9.8, Dr. H. Johnson measured here the brightness photo-electrically and determined it as 12^m20 on the photographic scale with a color index of 0^m72 which would make it only 11^m48 visually. The comet follows closely the ephemeris given last month but its southern declination is unfavorable for northern observers.

Two more expected periodic comets, KOPFF and TEMPEL (2), were not found in their predicted positions when their field was photographed here early this month, although the plates showed stars down to magnitude 20.

McDonald Observatory, Fort Davis, Texas, February 12, 1951.

General Notes

Dr. Arthur E. Bassett, former member and president of the Rittenhouse Astronomical Society, died in Swarthmore, Pa., on January 26, 1951, at the age of 64.

The Rittenhouse Astronomical Society,—The imperative need to understand the effects of atomic radiation in this time of civil defense mobilization led the officers of the Rittenhouse Astronomical Society to schedule the February meeting simultaneously with the Franklin Institute lecture by Dr. Richard A. Weiss, Chief of the Nucleonics Branch, Signal Corps Laboratories, Ft. Monmouth, N. J. The meeting was held on Friday, February 16, in the Lecture Hall, of the Franklin Institute.

The Cleveland Astronomical Society

Dr. Donald MacRae, of the Warner & Swasey Observatory, addressed the January 26th meeting of the Cleveland Astronomical Society. His topic was "Star Clusters in the Milky Way."

Before settling down to his main topic of galactic clusters, Dr. MacRae showed some interesting slides of spiral nebulae and globular clusters made from photographs taken with the 200-inch telescope. The resolution and detail shown in these slides were very striking.

The star density and star distribution in various clusters were pointed out on slides. The globular clusters may appear in any part of the sky but the galactic clusters are found only in or near the Milky Way. The speaker concentrated on two of these open, galactic clusters, namely the Pleiades and the Hyades.

After explaining the Russell-Hertzsprung diagram in which the absolute magnitudes of stars are plotted against their spectral classes, Dr. MacRae showed the results he obtained when making similar diagrams for the stars in the two clusters mentioned. The 24-inch Schmidt-Type telescope of the Warner and Swasey Observatory was used in obtaining the plates necessary for this study. The deviations from the regular Spectrum-Luminosity Diagram which the speaker found were marked and interesting and their interpretation continues to occupy his time and study.

An interesting question period followed the lecture. The Warner Memorial Auditorium was filled as usual.

HENRY F. DONNER, *Recording Secretary*

Western Reserve University, Cleveland 6, Ohio.

The Minor Planet Center at the Cincinnati Observatory is prepared to sell copies of the complete Minor Planet Ephemeris Volume to any amateurs at a cost of $1.00, plus 10c for postage. We also prepare a collection of ephemerides of Bright Planets, which are available at no charge, but will be sent in return for a self-addressed stamped envelope. Address requests to Dr. Paul Herget, The Cincinnati Observatory, Observatory Place, Cincinnati 8, Ohio.

Provisional Sunspot Numbers for January, 1951*

1	32	11	54	21	38
2	22	12	25	22	38
3	32	13	17	23	60
4	42	14	26	24	80
5	42	15	12	25	100
6	64	16	14	26	104
7	71	17	20	27	101
8	75	18	25	28	106
9	60	19	43	29	112
10	57	20	39	30	124
				31	111

Mean Value for January
R = 56.3

*From the Zurich Observatory, furnished by Mr. Neal J. Heines.

National Bureau of Standards Semicentennial

The year 1951 marks the fiftieth anniversary of the National Bureau of Standards. A large number of the principal scientific and technical organizations of the nation, in recognition of the role of the Bureau in science, have planned meetings in Washington in 1951 to honor the Bureau's Semicentennial. The present calendar of major meetings lists twenty-five. Some of the meetings have regularly been held in Washington in the past; most of them were planned for Washington by the societies in view of the Bureau's Semicentennial.

In addition, a number of committee conferences and meetings of local sections of societies will be held at the National Bureau of Standards. The Bureau is also planning a series of symposia on special topics, to be held during the year.

Created by Act of Congress on March 3, 1901, the Bureau is the principal agency of the Federal Government for fundamental research in physics, mathematics, chemistry, and engineering. The Bureau's activities are thus largely concerned with the physical sciences although the close inter-relationships of the major fields of science preclude the drawing of sharp lines of distinction. Considerable work, for example, is undertaken in biochemistry and biophysics, particularly projects relating to materials, processes, and instrumentation.

The history of the Bureau actually extends back to the Constitution, which gave cognizance of weights and measures to the Federal Government. An Office of Weights and Measures grew out of various acts of Congress beginning in 1830, and this Office was the immediate antecedent of the Bureau.

The scope of the Bureau's work is suggested by the names of its fifteen divisions: electricity, optics and metrology, heat and power, atomic and radiation physics, chemistry, mechanics, organic and fibrous materials, metallurgy, mineral products, building technology, applied mathematics, electronics, ordnance development, radio progagation, and missile development. The divisions in turn consist of several sections—totalling 108—organized as logical units of the divisions. In addition to laboratory work, the Bureau, by virtue of its staff and facilities,

is called upon to render scientific advisory services to the Government and industry. Its participation in the activities of scientific and engineering societies and bodies, both nationally and internationally, is necessarily extensive and varied.

The Duodecimal Society Annual Award

The annual Award of the Duodecimal Society of America was conferred on January 25 upon J. Halcro Johnston of Orkney, Scotland, in recognition of his contributions to mathematical science and, in particular, of his explorations of advantages of counting by dozens. Mr. Johnston was author of *The Reverse Notation*, published in England more than a decade ago, which demonstrated the use of a 12 base instead of 10 for counting, with negative digits as well as positive. He has also written in America on this subject. .

The occasion for the award was the annual meeting of the Duodecimal Society, held January 25 at the Gramercy Park Hotel in New York City. Harry C. Robert, Jr., of Atlanta, Georgia, presided, and the meeting brought together members from many states to discuss recent developments in the experimental use of Base Twelve in numeration, mathematics, weights and measures, and other branches of pure and applied science. Among speakers from the floor was Velizar Godjevatz, formerly of Yugoslavia, who has developed a musical notation on Base 12 which received the warm endorsement of George Bernard Shaw just before his recent death.

This is the first time the Society's award has gone overseas. Previous recipients were F. Emerson Andrews of Tenafly, New Jersey; George S. Terry of Hingham, Massachusetts; the late F. Howard Seely of Oakland, California; Ralph H. Beard of New York City; and Harry C. Robert, Jr., of Atlanta, who this year made the presentation.

The Moon

(February 7, 1951)

Thy crescent glory, wondrous fair,
  Did crown the sky that night,
When lovely Venus joined thee there,
  Like jewel dazzling bright.

Methinks she fondly clasped thy hand
  There in the twilight dim,
And then appeared like pendant bright
  Near outer, lower rim.

She sparkled like a diamond rare,
  Then, like a joyful eye,
And snow-draped earth reflected back
  The radiance in the sky.

—Lisa Odland

2649 35th Ave. So.,
Minneapolis, Minnesota.

Book Reviews

Transactions of the International Astronomical Union, Volume VII. (Cambridge University Press, 51 Madison Avenue, New York 10, N. Y. 552 pages. $7.50.)

The series to which this volume belongs is being built up at irregular intervals. Volume I appeared in 1922, Volume II in 1925, Volume III in 1928, Volume IV in 1932, Volume V in 1935, Volume VI in 1938, and now, after a lapse of twelve years, Volume VII in 1950. The normal interval is three years, in keeping with the schedule which contemplates a meeting of the I.A.W. every three years. The four-year interval from 1928 to 1932 was designed to bring the meeting at a time and place so that a total eclipse of the sun might be observed. The eclipse was total in New England on August 31, 1932. The longer interval from 1938 to 1950 was due to the suspension of meetings during the period of World War II.

Volume VII is principally a report of the seventh general assembly of the I.A.U. which took place at Zürich from August 11 to August 18, 1948, edited by the General Secretary, Dr. J. H. Oort, Leiden, Holland. The Volume of 552 pages is similar to earlier volumes in the series. It is divided into six parts, *viz.*, I. Inaugural Ceremony and General Assembly, Report of the Executive Committee; II. Resolutions Adopted; III. Reports of Meetings of Commissions; IV. Symposia; V. Statutes of the I.A.U.; VI. Membership lists of Commissions and Committees and Alphabetical list of total membership.

Because of the international character of the members in attendance at the assembly, more than one language had to be used. This fact is carried into the report as given in Volume VII, in which one finds pages in English, French, and German, the preponderance being in English. Since the outstanding astronomers of the world are included in this membership, this report of the deliberations naturally discloses the trend of astronomical thought at the time. The field of activity is represented by thirty-five commissions, and hence the totality of the reports shows comprehensiveness as well as minutiae.

At the final meeting of the assembly held on August 18, officers for the new triennium were elected as follows:

President, Professor Bertil Lindblad, Stockholm, Sweden.
Vice-President, Professor V. A. Ambartsumian, Erevan, Armenia.
Vice-President, Professor Otto Struve, University of California, U. S.
General Secretary, Professor Bengt Strömgren, Copenhagen, Denmark.

C.H.G.

The History of Nature, by C. F. von Weizsäcker. Translated from the German by Fred D. Wieck. (The University of Chicago Press, 1949.)

C. F. von Weizsäcker who is at present a professor of physics at the University of Chicago sketches in the twelve chapers of this book what he calls "the history of nature." At least seven chapters deal most exclusively with cosmological and cosmogonical problems. The basic idea to conceive the whole of nature, including organic life and human history, as a single huge process subject to the same laws is certainly nothing essentially new. It acquired great popularity already in the last century. A comparison of Weizsäcker's ideas with, for instance, those of Svante Arrhenius will, however, bring into focus the important differences which separate the modern cosmogony from that of the classical period.

While for Arrhenius the world-process was essentially cyclical ("from nebula to nebula") and thus did not possess any definite direction, for Weizsäcker it is essentially a *history* in true sense, moving always in one definite sense indicated by the second law of thermodynamics. For Arrhenius the cyclical character of the world-machine implied its eternal duration, that is the absence of its beginning in the past; Weizsäcker, on the other hand, leans distinctly toward the hypothesis of the temporal beginning of the whole universe which was suggested already before him by Jeans, Lemaître, Whittaker, and others (pp. 59, 70). He believes that the large amount of empirical evidence points toward this conclusion. The author promises a more extensive discussion of the dilemma of infinity in his new coming book "The World of Physics."

More open to question seems to be the author's interpretation of organic life and his solution of the "mind-body" (or rather, consciousness-matter) problem. The organic evolution according to him is a special case of the continuous development of the physical world toward more and more probable state and, eventually, toward the "heat-death." A great number not only of philosophers but also of biologists and physicists would hardly agree with the view of the author according to which the higher and more complex forms of organic life are physically more probable than the simple and undifferentiated protozoas or viruses. Also Weizsäcker's acceptance of the "double-aspect theory" as a solution of the mind-body problem ignores all serious objections which have been raised against it by philosophers as well as by psychologists as early as at the beginning of this century. It is obvious that when Professor Weizsäcker ventures outside of his own field his thought moves along more traditional lines.

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H. C. Schumacher and the Observatory at Altona during the War of 1848-1850, by Axel V. Nielsen. (Meddelelser fra Ole Rømer Observatoriet i Århus, Nr. 22, 1951. 39 pp; in English.)

This publication of the observatory at Århus, Denmark, is a useful contribution to the history of nineteenth century astronomy. Heinrich Christian Schumacher (1780-1851) is best remembered today as the founder in 1821 of the oldest astronomical magazine still published, the *Astronomische Nachrichten*. He was fittingly called the postmaster general of astronomy, bith for the *Nachrichten*, which speedily became the leading medium for publication by the entire astronomical world, and for his widespread scientific correspondence, in which he wrote 1500 letters a year without secretarial help. Under Schumacher's directorship, the Danish Observatory at Altona became "the center of international relations between astronomers of that period."

Dr. Nielsen's pamphlet deals particularly with Schumacher's difficulties during the last years of his life, 1848-1851, when civil war in Denmark threatened the existence both of the *Nachrichten* and of the Altona Observatory. An interesting measure of Schumacher's scientific stature is afforded by the fact that in 1848 the British and Russian governments made strong appeals to the King of Denmark for the continuance of his work. This hitherto obscure chapter in astronomical history has now been clarified by Dr. Nielsen in very readable form.

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